Engineering Library

FEB 23 1927

The Engineer.

Established 1856.

Registered as a Newspaper.

OFFICE FOR ADVERTISEMENTS & PUBLICATION, 33, NORFOLK ST., STRAND, LONDON, W.C. 2.

VOL. CXLIII.—No. 3708] LONDON: FRIDAY EVENING, FEBRUARY 4, 1927 [PRICE { WITH SUPPLEMENT } ONE SHILLING BY IRLAND POST 1s. 3d.

PUBLIC NOTICES

The Director - General, India Store Department, Branch No. 15, Belvedere-road, Lambeth, S.E. 1, invites TENDERS for—
2,000,000 MILD STEEL COTTER LINERS and 500,000 GIB LINERS.
Tenders due on the 15th February, 1927.
Specifications and forms of Tender obtainable from the above at a fee of 5s. per set, which will not be returned. 4680

A Technical Officer, Grade II., is REQUIRED at the Royal Aircraft Establishment, S. Farnborough, for duties in the technical supervision of the application of all equipment used in aeroplanes built under contract for the Air Ministry. The duties necessitate visits to contractors' works. Candidates should have had a technical education to the standard of the B.Sc. Degree with drawing-office and workshops experience and should have a practical knowledge of modern aircraft, wireless and electrical apparatus. It may occasionally be necessary for the officer to fly as passenger in aircraft. Preference will be given to applicants having flying experience in Service aircraft.
Salary £250-20-350 plus Civil Service bonus, giving total remuneration of £361 to £485 at present rates of C.S.B.
For form of application apply, quoting A. 127, to the CHIEF SUPERINTENDENT. 4657

Civil Engineer Required by the GOVERNMENT of NYASALAND for a tour of 36 months' service and possible extension. Salary £500 a year. Outfit allowance of £30 on first appointment. Free quarters and passages and liberal leave on full salary. Candidates, aged 25-30, must be A.M.I.C.E. or hold equivalent professional qualifications and have had good experience on road survey and construction. Experience in the design and erection of steel and timber bridges and buildings is also necessary. Must be able to ride a motor bicycle.—Apply at once by letter, stating age, qualifications and experience, and mentioning this paper, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, Westminster, S.W. 1, quoting M/15160. 4682

Civil Service Commission.
FORTHCOMING EXAMINATION.
MALE CARTOGRAPHERS in the Hydrographic Department of the Admiralty (19-25, with extension in certain cases).—Regulations and particulars are obtainable from the SECRETARY, Civil Service Commission, Burlington-gardens, London, W. 1, together with the form on which applications must be made. The latest date for the receipt of application forms is 8th March. 4618

Institution of Structural Engineers.
MODIFIED EXAMINATION FOR ASSOCIATE-MEMBERSHIP.
This Examination is held quarterly for candidates of and over 25 years of age having 10 years' practical experience, including time served in articles. It consists of a problem in design with a little additional work, which is carried out by the candidate at his own home. The NEXT EXAMINATION will be held on FEBRUARY 19th, and entries should reach me before February 14th. Syllabus and full particulars from the under-noted.
MAURICE G. KIDDY, F.I.S.A.,
Secretary.
10, Upper Belgrave-street, S.W. 1. 4479

Administrative County of LONDON.
SCAVENGING, &c., OF THAMES EMBANKMENTS AND BRIDGES.
The London County Council invites TENDERS for the SCAVENGING, &c., of the THAMES EMBANKMENTS and BRIDGES for a period of twelve months, commencing 1st April, 1927.
Persons desiring to submit Tenders may obtain the form of Tender, &c., on application to the Chief Engineer of the Council at the Old County Hall, Spring-gardens, S.W. 1, upon payment of the sum of £3 by cheque or draft to the order of the London County Council. This amount will be returnable only if the tenderer shall have sent in a bona fide Tender and shall not have withdrawn the same. Full particulars of the work may be obtained on personal application, and the contract documents may be inspected before payment of the fee.
No Tender received after 4 p.m. on Monday, 21st February, 1927, will be considered.
The contractor will be bound to observe the provisions of a fair wages clause, the terms of which are set out fully in the instructions for Tender and form of contract and in the "London County Council Gazette."
The Council does not bind itself to accept the lowest or any Tender.
MONTAGU H. COX,
4639 Clerk of the London County Council.

Administrative County of LONDON.
REMOVAL OF SEWER DEPOSIT.
The London County Council invites TENDERS for the REMOVAL and DISPOSAL of SEWER DEPOSIT and other MATERIALS in connection with the main drainage, &c., services for four districts—two north of the Thames and two south of the Thames, east and west respectively, for a contract for twelve months, commencing 1st April, 1927.
Persons desiring to submit Tenders may obtain the schedule of prices, form of Tender, &c., on application to the Chief Engineer, Old County Hall, Spring-gardens, S.W. 1, upon payment of the sum of £1 by cheque or draft to the order of the London County Council. This amount will be returnable only if the tenderer shall have sent in a bona fide Tender and shall not have withdrawn the same. Full particulars of the work may be obtained upon personal application, and the contract documents may be inspected before payment of the fee.
The contractor will be bound to observe the provisions of a fair wages clause, the terms of which are set out fully in the instructions for Tender and form of contract and in the "London County Council Gazette."
No Tender received by the Clerk of the Council at the County Hall, Westminster Bridge, S.E. 1, after 4 p.m. on Monday, 21st February, 1927, will be considered.
The Council does not bind itself to accept the lowest or any Tender.
MONTAGU H. COX,
4640 Clerk of the London County Council.

The Engineer

PRINCIPAL CONTENTS OF THIS ISSUE.
ARRANGED FOR CARD INDEXING.

A British Steam Turbine Locomotive (With a Two-Page Drawing). THE ENGINEER, 4 - 2 - 27.

Coilers for Cold Strip Rolling Mills—No. II. (C. E. DAVIES.) THE ENGINEER, 4 - 2 - 27.

Soldering and Welding Aluminium. (A. EYLES.) THE ENGINEER, 4 - 2 - 27.

High-Pressure Steam Plants. (MELLANBY & KERR.) THE ENGINEER, 4 - 2 - 27.

British-built Dining Cars for the Continent. THE ENGINEER, 4 - 2 - 27.

Work Hardening Properties of Metals. (E. G. HERBERT.) THE ENGINEER, 4 - 2 - 27.

New Type of Phonoscope. THE ENGINEER, 4 - 2 - 27.

Some Large Electric Transformers. THE ENGINEER, 4 - 2 - 27.

Steam Boiler Wagon for Heating Electric Trains. THE ENGINEER, 4 - 2 - 27.

PUBLIC NOTICES

Bombay, Baroda and Central INDIA RAILWAY COMPANY.
The Directors are prepared to receive up to Noon on Wednesday, 16th February, TENDERS for the SUPPLY of :—
1. CHEMICALLY DRESSED WAGON COVERS, &c.
2. WOOD SCREWS, SPLIT PINS, &c.
Tenders must be made on forms, copies of which, with specification, can be obtained at these offices on payment of 10s. each (which will not be returned).
The Directors do not bind themselves to accept the lowest or any Tender.
S. G. S. YOUNG,
Secretary.
Offices : The White Mansion, 91, Petty France, S.W. 1.
31st January, 1927. 4672

Scarborough Corporation.
NEW IRTON WATER SCHEME.
CONTRACT NO. 10.
RESERVOIR REINFORCED CONCRETE ROOFING.
The Corporation invite from experienced reinforced concrete contractors TENDERS for the CONSTRUCTION of a REINFORCED CONCRETE ROOF, covering 7600 square yards, at Osgodby, near Scarborough.
The columns will be of pre-cast reinforced concrete, with alternative schemes for reinforced concrete roofing. The work will also include the strengthening of the existing floor, pipe laying and accessories, soiling and embanking.
Copies of the conditions, specification, schedule of prices and form of Tender, prepared by the Engineer, Dr. Herbert Lapworth, M. Inst. C.E., 25, Victoria-street, Westminster, may be obtained on application to the undersigned on or after Thursday, February 3rd. The application must be accompanied by a sum of £5, which will be refunded on return of the documents within seven days or after the receipt of a bona fide Tender and the documents required.
Facilities for examining the drawings, for inspecting the site and general information can be obtained on application to Mr. Herbert Richardson, M. Inst. W.E., the Water and Streets Engineer to the Corporation, Town Hall, Scarborough.
Tenders are to be sent in on the form supplied, and with the annexed documents must be enclosed in a sealed cover, endorsed "New Irton Water Scheme: Tender for Contract No. 10," addressed to and reaching the undersigned not later than 10 a.m. on Thursday, February 24th.
It is particularly requested that none but experienced reinforced concrete specialists should apply.
The Corporation do not bind themselves to accept the lowest or any Tender.
SYDNEY JONES,
Town Clerk.
Town Hall, Scarborough.
24th January, 1927. 4643

PUBLIC NOTICES

Corporation of Doncaster.
ELECTRICITY DEPARTMENT.
TENDERS are INVITED for the PURCHASE, DISMANTLING, and REMOVAL from the Generating Works, Grey Friars-road, of the following superseded PLANT :—
ONE 1250 K.V.A. TURBO-ALTERNATOR, 3-phase, 50 cycles, 3000-3300 volts, speed 3000 r.p.m.
TURBINE (Willans and Robinson), steam pressure 200 lb. per square inch. ALTERNATOR (Siemens Bros.), and with Surface Condenser and all Auxiliaries.
The plant is in first-class mechanical and electrical condition and may be inspected upon application to the undersigned, from whom any further particulars can be obtained.
S. R. WINDLE,
Borough Electrical Engineer.
Electricity Offices, Grey Friars-road, Doncaster. 4598

Pontefract Corporation Waterworks.
CONTRACT NO. 3.
BORE-HOLE AT EGGBOROUGH.
The Corporation of Pontefract invite TENDERS from firms of competent Boring Contractors for PUTTING DOWN a BORE-HOLE, 36in. and 33in. diameter, to the depth of 450ft., and LINING with STEEL TUBES, at the site of their new Waterworks at Eggborough, and also MAKING a PUMPING TEST of the yield of water from the Bore-hole.
Copy of the specification and general conditions of contract and the schedule of works may be obtained from the Consulting Engineer, Mr. F. Walter Hodson, M. Inst. C.E., at Bank Chambers, Loughborough, on deposit of cheque for Five Guineas, which will be refunded to bona fide tenderers on return of the papers.
Tenders, on the form supplied, are to be sent to the undersigned not later than 20th February, 1927.
The Corporation do not bind themselves to accept the lowest or any Tender.
F. M. FARMER,
Town Clerk.
Municipal Offices, Pontefract, 22nd January, 1927. 4600

The Madras and Southern MAHRATTA RAILWAY COMPANY, Limited, 25, Buckingham Palace-road, Westminster, S.W. 1, invite TENDERS for :—
(1) TWO ENGINE TURNTABLES, 65ft. diameter.
(2) GIRDER BRIDGES, comprising Spans of 9ft., 40ft., and 41ft. 9in. clear, a total approximate tonnage of 216.7 tons.
Tenders are due in as follows :—
(1) Tuesday, 22nd February, 1927, by 2 p.m.
(2) Tuesday, 1st March, 1927, by 10.30 a.m.
Tender forms obtainable at above address; fee One Guinea each, which is not returnable.
The Directors do not bind themselves to accept the lowest or any Tender. 4661

PUBLIC NOTICES

Lochaber Water Power.
PIPE LINE.
The NORTH BRITISH ALUMINIUM COMPANY, Ltd., invite TENDERS for the MANUFACTURE and SUPPLY of WELDED STEEL PIPES for the Pipe Line of their Lochaber Water Power Works.
Copies of the plans, specification, &c., may be obtained from the Company's Engineers, Messrs. C. S. Mei and Buchanan, 16, Victoria-street, Westminster, London, S.W. 1, upon payment of £10 (by cheque), which will be returned upon the receipt of a bona fide Tender, together with the drawings supplied.
Sealed Tenders, endorsed "Lochaber Water Power, Tender for Pipe Line," addressed to the Secretary, The North British Aluminium Company, Ltd., Adelaide House, King William-street, London, E.C. 4, must be received before 10 a.m. on Tuesday, 1st March, 1927.
The Company does not bind itself to accept the lowest or any Tender.
G. W. JEFFERY,
4689 Secretary.

Surrey County Council.
HIGHWAYS AND BRIDGES DEPARTMENT.
The Surrey County Council invite TENDERS for the WORKS to be carried out in the CONSTRUCTION of a FERRO-CONCRETE BRIDGE of six spans, totalling 315ft., over the Southern Railway and Upper Mulgrave-road in the Parish of Cheam.
Copies of the form of Tender, instructions to persons desirous of tendering, and bill of quantities may be obtained from the undersigned, and the form of contract, general conditions, specification and drawings may be examined at the office of the County Surveyor on weekdays (except Saturdays) from 10 a.m. to 4.30 p.m., on and after Tuesday, the 1st February, on payment of a deposit of Ten Guineas, which will be refunded upon receipt of the above-mentioned documents complete with a bona fide Tender, and each Tender must be submitted enclosed in a sealed envelope endorsed "Tender for Bridge over the Southern Railway and Upper Mulgrave-road, Cheam," and lodged not later than 9 a.m. on the 16th February, 1927.
The Council does not bind itself to accept the lowest or any Tender.
W. P. ROBINSON, A.M. Inst. C.E.,
County Surveyor.
County Hall Annexe, Kingston-on-Thames,
27th January, 1927. 4647

Sudan Government Railways REQUIRE the SERVICES of a DISTRICT LOCOMOTIVE SUPERINTENDENT. Age 26 to 32, preferably single. Candidates should have been trained on a British Railway or in a Locomotive Builder's Works, and should have good knowledge of the working of a Locomotive Department. A.M.I.C.E. degree or equivalent. Commencing salary £E480 to £E540 per annum, according to age and qualifications (£E1 equals £1 0s. 6d.). Progressive and pensionable post if satisfactory. Strict medical examination. Free first-class passage. Liberal leave and assisted passages.—Apply by letter to ADVISORY ENGINEER, Sudan Government London Office, Wellington House, Buckingham-gate, S.W. 1, marking envelope "District Locomotive Superintendent." 4646

The Municipality of Malacca, STRAITS SETTLEMENTS.
MUNICIPAL ENGINEER.
ADVERTISEMENT.
The Municipal Commissioners of the Town and Fort of Malacca REQUIRE a MUNICIPAL ENGINEER, age 28 to 35, preferably unmarried, on a four years' agreement, with possible extension.
Candidates must have received a good general and technical education and must be corporate members of the Institution of Civil Engineers.
The duties of the appointment comprise those usually carried out by a Borough Surveyor, including the construction and administrative work connected with Roads, Buildings, Bridges, Surface Drainage, Sewerage, Water Supply, and Conservancy. Training and experience in a Borough Surveyor's office are therefore essential. Preference will be given to candidates having special experience in Drainage and Sewerage Schemes, and accustomed to the control and direction of staff and workmen, and to the carrying out of works departmentally.
Salary 7200 dollars for the first year, 7500 dollars for the second year, 7800 dollars for the third year, and 8100 dollars for the fourth year of the agreement. The value of the dollar is 2s. 4d. sterling, and the pay of the appointment for the first year is therefore £840. Free unfurnished quarters will be provided. An allowance for the maintenance of a motor car or motor cycle for use on duty will be granted. Free passage will be provided, with half-pay during the voyage out. The selected candidate must pass an approved medical examination.
Applications, stating age and place of birth, and whether married or single, and giving details of education, training, and experience, referring to the above requirements in detail, and stating when free, accompanied by copies (not originals) of testimonials, and also personal references, must be lodged with Messrs. PEIRCE and WILLIAMS, MM. Inst. C.E., 64, Victoria-street, London, S.W. 1, Agents to the Commissioner, not later than Wednesday, 9th February, 1927. Further particulars, if desired, can be obtained from the Agents. 4617

SITUATIONS OPEN, Page 2.
SITUATIONS WANTED, Page 2.
PARTNERSHIPS, Page 3.
EDUCATIONAL, Page 3.
AGENCIES, Page 3.
MISCELLANEOUS, Page 2.
AUCTIONS, Pages 4 and 98.
MACHINERY, &c., WANTED, Page 2.
FOR HIRE, Page 3.
FOR SALE, Pages 4 and 8.
PATENTS, Page 3.
BUSINESSES and PREMISES (For Sale, etc.), Page 4.
WORK WANTED, Page 4.

For Advertisement Rates see Leader Page.

INDEX TO ADVERTISEMENTS Page 97.

SITUATIONS OPEN

COPIES OF TESTIMONIALS, NOT ORIGINALS, UNLESS SPECIFICALLY REQUESTED.

WANTED, INSPECTION SUPERINTENDENT for Mechanical Side of large firm of Commercial Motor Vehicle Manufacturers; capable of controlling all inspection work on component parts and the testing of units and finished chassis; must be good organiser with first-class experience.—Address, stating age and salary required, 4645, The Engineer Office. 4645 A

WANTED, MAN to Take Charge of Small Power Station with West of England Manufacturers. Must have Board of Trade Certificate and be capable of ensuring efficient results in boiler-house.—Address, stating salary required, 4665, The Engineer Office. 4665 A

WANTED, SUPERVISING ENGINEER, with good experience of Erection of Steelwork, London and country. State qualification, previous experience and salary.—Address, P2721, The Engineer Office. P2721 A

APPLICATIONS are INVITED for the POST of WHOLE-TIME REPRESENTATIVE for Provincial Office. Essentials are (1) selling ability, (2) connection with steam users, (3) some engineering knowledge. The terms offered are salary and commission, with possibility of very considerable income. Every assistance given from head office.—Address, P2720, The Engineer Office. P2720 A

ASSISTANT SECRETARY REQUIRED for a Well-established Technical Institution in London. Commencing salary £400 per annum, with good prospects. Applicants must have public school education, engineering training and good appearance and be able to write good English. Age about 30.—Address, 4691, The Engineer Office. 4691 A

ASSISTANT to CHIEF ENGINEER REQUIRED for Large London Factory; must have works and drawing-office experience. One with mechanical engineering degree or equivalent training preferred.—Write, stating age, salary required, and full details of experience, to Z. T. 591, care Deacon's, Fenchurch-avenue, E.C. 3. 4692 A

CEMENT TESTER, &c., REQUIRED for Cement Works in Midlands; used to calcimeter. Fair prospects for a keen man.—Address, stating age, experience, when disengaged, whether married or single, and salary required, 4650, The Engineer Office. 4650 A

CONSTRUCTIONAL ENGINEER REQUIRED as Leading Designer; must be fully competent in the Design of Steel and Concrete Structures for General Civil Engineering Work. Only men with first-class experience and technical knowledge will be considered.—Applications, stating age, experience and salary required, should be addressed 4674, The Engineer Office. 4674 A

CONTRACTOR'S AGENT WANTED for Job near London; extensive experience in Reinforced Concrete essential.—Address, stating age, experience and salary required, 4649, The Engineer Office. 4649 A

ELECTRICAL and MECHANICAL ENGINEER, with sound technical training, WANTED for Federated Malay States. Estimating experience and salesmanship strictly essential. Under 30 years of age, preferably single.—Reply, Box M.S. 720, c.o. Dawson's Advertising Offices, 118, Cannon-street, E.C. 4. 4641 A

ENGINEER WANTED for Large Chemical Factory in East London.—Reply, giving full particulars of experience, age, salary required, to ENGINEER, Boake, Roberts, Carpenters-road, Stratford, E. 4662 A

HYDRO-ELECT. ENGINEER REQD., Italy; must have Hydro-elect. or Civil Waterworks Exp., and fluent Italian. £800/1200 p.a. — Apply, LAURIE'S, Employment Specialists, 28, Basinghall-st., E.C. 2. No preliminary fee. 4676 A

PETTERS Limited have VACANCY in their London Office for ASSISTANT SALES MANAGER and REPRESENTATIVE of their Ipswich works. Successful applicant must be qualified engineer, with good London experience in selling Internal Combustion Engines. State age and salary required.—Letter applications only, 75B, Queen Victoria-street, E.C. 4. 4663 A

PUBLICITY.—YOUNG MAN of Good Education and engineering experience, able to originate ideas for Folders and Catalogues and Control Advertising Department. Particulars of experience, age and salary.—Address, P2746, The Engineer Office. P2746 A

REINFORCED CONCRETE DESIGNERS (TWO) REQUIRED, with specialist training.—Address applications, stating age, experience and salary required, 4659, The Engineer Office. 4659 A

TWO ENGINEER REPRESENTATIVES REQUIRED by firm of Pneumatic Tool Manufacturers; must have undoubted experience of Pneumatic Tools and Plant, also good knowledge of Glasgow and Tyneside districts respectively.—Address, stating experience, age and salary expected, 4656, The Engineer Office. 4656 A

WANTED, a First-rate DRAUGHTSMAN, Experienced in Gas and Chemical Plant for Contractor's work.—State age, experience and salary expected to E. and J. DEMPSTER, Ltd., Oldham-road, Manchester. 4652 A

WANTED for Westminster, DRAUGHTSMAN, maximum age 25, college training, at least three years' Civil or Mechanical Engineering Experience in Designing and Constructing Industrial Works. Preference given to men with experience of plants for the manufacture of Cement, Brick and Clay Products. Competent to calculate and design under supervision.—Address, stating age, training and experience, giving dates and wages required, 4675, The Engineer Office. 4675 A

WANTED Temporarily, but with View to Permanency, thoroughly practical DRAUGHTSMAN for Mechanical Details. Must be competent make all calculations, knowledge of Oil Refining Plant an advantage.—Address, stating wages, experience, and references, P2729, The Engineer Office. P2729 A

COMPETENT DRAUGHTSMAN REQUIRED, with experience in all types of Electric and Steam Cranes.—Apply, giving full particulars of experience, age, and salary required, to THOMAS SMITH and SONS (RODLEY), Ltd., Steam and Electric Crane Works, Rodley, Leeds. 4686 A

DRAUGHTSMAN REQUIRED by a Large Firm of Commercial Vehicle Builders in the South of England. Must have a thorough knowledge of up-to-date Chassis Design.—Address, stating age, full particulars of experience, and salary required, 4685, The Engineer Office. 4685 A

DRAUGHTSMAN WANTED for Machinery Layouts and Mechanical Details, N.W. London. State age, experience, and salary.—Address, 4671, The Engineer Office. 4671 A

INDIA.—REQUIRED by British Firm of Engineers, DRAUGHTSMAN, accustomed to Roof, Bridge, and Structural Steel Work, able to work out stresses and prepare designs, estimates and detail drawings. Must be a bachelor, age 23 to 25.—Apply, stating age and particulars of experience, to Z. H. 582, c/o Deacon's Advertising Agency, Fenchurch-avenue, E.C. 3. 4681 A

REQUIRED, First-class MECHANICAL DRAUGHTSMEN and DESIGNERS for London. Application by letter, giving particulars of age, experience, salary expected.—Address, 4668, The Engineer Office. 4668 A

Messrs. Longmans & Co.'s List.

THE WHITWORTH BOOK.

Prepared by the Whitworth Society (an Association of Whitworth Scholars, Exhibitioners and Prizemen. Honorary Editor, DAVID ALLAN LOW (Whitworth Scholar), M.I. Mech. E. With Portrait of Sir Joseph Whitworth, Bart. 8vo. 10s. 6d. net.

This book, besides being a sort of "Who's Who" of Whitworth men, contains a Memoir of Sir Joseph Whitworth, and gives an account of the formation of the Whitworth Scholarships.

"A book which will be treasured and honoured by all Whitworth men who hold in veneration the name of their great benefactor."—*The Engineer.*

CIVIL ENGINEERING SPECIFICATIONS AND QUANTITIES.

By G. S. COLEMAN, D.Sc. (Eng.), A.M. Inst. C.E., Assoc. M. Inst. Mun. & Cy.E. and G. M. FLOOD, B.Sc. (Eng.), A.M. Inst. M. & Cy. E., A.M.I. Struct. E.
With Diagrams. 8vo. 10s. 6d. net.

REINFORCED CONCRETE DESIGN.

By G. P. MANNING. B.Eng., Assoc. M. Inst. C.E.
With Diagrams. 8vo. 21s. net.

STRUCTURAL ENGINEERING.

By JOSEPH HUSBAND, M. Inst. C.E., and WILLIAM HARBY.
Third Edition. With 393 Diagrams. 8vo, 16s. net.

THEORY OF STRUCTURES.

By ARTHUR MORLEY, D.Sc., M.I. Mech. E. With 320 Diagrams. 8vo. 12s. 6d. net.

STRENGTH OF MATERIALS.

By ARTHUR MORLEY, D.Sc., M.I. Mech. E. With 267 Diagrams and numerous Examples. Fifth Edition. Crown 8vo. 12s. 6d. net.

ELEMENTARY APPLIED MECHANICS.

By ARTHUR MORLEY, D.Sc., M.I. Mech. E., and WILLIAM INCHLEY, B.Sc., A.M.I. Mech. E. With 285 Diagrams and numerous Examples. Crown 8vo, 5s. net.

MECHANICS APPLIED TO ENGINEERING. Volume I.

By JOHN GOODMAN, Wh. Sch., M. Inst. C.E.
With 741 Illustrations and numerous Examples. NINTH EDITION. Crown 8vo. 14s. net.

APPLIED MECHANICS.

Embracing Strength and Elasticity of Materials. Theory and Design of Structures, Theory of Machines and Hydraulics.
By DAVID ALLAN LOW (Wh. Sch.), M.I. Mech. E.
With 850 Illustrations and 780 Exercises. 8vo. 12s. 6d. net.

MECHANICS FOR ENGINEERS.

A Text-book of Intermediate Standard. By ARTHUR MORLEY, D.Sc., M.I. Mech. E. With 200 Diagrams and numerous Examples. Crown 8vo. 6s. 6d. net.

MECHANICS OF TEXTILE MACHINERY.

By WILLIAM A. HANTON, M.Sc. (Tech.). With 192 Diagrams. 8vo. 12s. 6d. net.

MACHINE DESIGN, CONSTRUCTION & DRAWING.

By HENRY J. SPOONER, C.E., M.I. Mech. E., A.M. Inst. C.E., etc. With 126 Tables and over 600 Figures. Fifth Edition, Revised and Enlarged. 8vo. 21s. net.

FRICTION.

By T. E. STANTON, C.B.E., D.Sc., F.R.S., M. Inst. C.E., M.I. Mech. E.
With Diagrams. 8vo. 12s. 6d. net.

AN INTRODUCTION TO THE STUDY OF ALTERNATING CURRENTS.

By ALBERT E. CLAYTON, D.Sc. (Engineering) Lond., A.M.I.E.E.
With Diagrams. 8vo. 10s. 6d. net.

HIGH VACUA.

By G. W. C. KAYE, O.B.E., M.A., D.Sc., F.Inst.P.
With 91 Illustrations. 8vo. 10s. 6d. net.

APPLIED ELASTICITY.

By JOHN PRESCOTT, M.A., D.Sc. 8vo. 25s. net.
"A treatise on Mathematical Theory which can be read with understanding by the engineering student."—*Science Progress.*

PRACTICAL GEOMETRY AND GRAPHICS.

By DAVID ALLAN LOW (Whit. Sch.), M.I. Mech. E.
With over 800 Illustrations and over 700 Exercises. 8vo. 9s. net.

HEAT ENGINES.

Embracing the Theory, Construction, and Performance of Steam Boilers, Reciprocating Steam Engines, Steam Turbines, and Internal Combustion Engines.
A Text-book for Engineering Students.
By DAVID ALLAN LOW (Whit. Sch.), M.I. Mech. E.
With 656 Illustrations and 315 Exercises. 8vo. 15s. net.

Longmans' Electrical Engineering Series.

THE DIAGNOSING OF TROUBLES IN ELECTRICAL MACHINES.

By MILES WALKER, M.A., D.Sc., M.I.E.E. With Illustrations. 8vo, 32s. net.

THE SPECIFICATION AND DESIGN OF DYNAMO-ELECTRIC MACHINERY.

By MILES WALKER, M.A., D.Sc., M.I.E.E. With Illustrations. 8vo, 36s. net.

POWER HOUSE DESIGN.

By Sir JOHN F. C. SNELL, M. Inst. C.E. With 20 Plates and 202 Illustrations.
Second Edition. 8vo, 42s. net.

LONGMANS, GREEN & CO., LTD., 39, Paternoster Row, London, E.C. 4.

SITUATIONS OPEN (continued)

FOUNDRY FOREMAN.

REQUIRED for Aluminium Foundry in London for intricate experimental work. Must have held a similar position previously.—Address, stating age, full details of experience, and salary required, 4666, The Engineer Office. 4666 A

REQUIRED for Seamless Tube Rolling Mills, energetic and experienced FOREMAN, with first-class references. State age, full qualifications and salary required.—Address, 4673, The Engineer Office. 4673 A

SITUATIONS WANTED

WANTED, A CHANGE.—TWO FRIENDS (24, 25 respectively) SEEK SITUATIONS as SHIFT ENGINEERS; thorough exp. erecting, testing of single and multi-cyld. horizontal gas and heavy oil engines.—Address, P2748, The Engineer Office. P2748 B

AN OPPORTUNITY OCCURS to SECURE the SERVICES of TWO widely experienced energetic ENGINEERS (combination or individually). Willing undertake reorganisation of works. Ability to lay out, to improve output and reduce costs, initiate and control planning, progress buying, rate fixing, inspection, costing and D.O. depts. Sound knowledge of stores systems. Responsible administrative experience in large engineering works. Able introduce good business. Present very successful contract terminates March.
Address, P2740, The Engineer Office. P2740 B

CIVIL ENGINEER, A.M.I.C.E. (Middle-aged), will be OPEN for ENGAGEMENT end of Feb. Extensive experience home and U.S.A. on surveys, designs and responsibly in charge of construction of public works of a varied character—roads and land development, water supply with impounding and service reservoirs, large mains, &c., drainage embracing tunnel sewers and disposal works, piling and general construction. Located London.—Address, P2747, The Engineer Office. P2747 B

COMMERCIAL MECHANICAL ENGINEER (23), 6 years shops and offices, exp. home and abroad, SEEKS POSITION in Sales Dept. of Manufacturers; keen salesman; ex. refs.—Address, P2725, The Engineer Office. P2725 B

ENGINEER DESIGNER, Exceptional Ability, Wide experience, mechanical, electrical and power plants, DESIRES POST, or PREPARES DRAWINGS. Moderate remuneration.—Address, P2728, The Engineer Office. P2728 B

ENGINEER, 1st Class B.O.T. Certificate, held position chief oil tankers, electric, refrigerating, DESIRES POSITION, control or otherwise; testimonials.—Address, P2743, The Engineer Office. P2743 B

ENGINEER (24), SEEKS POST, Home or Abroad; 9 years' exper. gen. shop and on shift, Diesel oil, steam, suction gas, elec. gen. plants. Good refs.—Address, P2736, The Engineer Office. P2736 B

ENGINEERS' or CONTRACTORS' STORES.—STOREKEEPER, 22 years chief railway stores, Purchase, costing, shipping and transport.—Address, P2750, The Engineer Office. P2750 B

MECHANICAL ENGINEER DESIRES POST; 25 years' wide experience in general engineering and maintenance work, capable of taking full control. Good references.—Address, P2733, The Engineer Office. P2733 B

STEEL MAKER, with Over 20 Years' Practical experience, DESIRES CHANGE. Open-hearth or electric. One of pioneers of electric process. Present position control of electric steel plant.—Address, P2734, The Engineer Office. P2734 B

METALLURGICAL ASSISTANT to the Above SEEKS RE-ENGAGEMENT. Sound all-round experience of works and laboratory. Position required, Works Metallurgist or Steel Plant Control; electric preferred.—Address, P2735, The Engineer Office. P2735 B

PRODUCTION PLANNING AND PROGRESS.—YOUNG MAN (25), workshop and technical experience, DESIRES to EXTEND EXPERIENCE in above. Earnest and energetic; willing to travel.—Address, P2724, The Engineer Office. P2724 B

STRUCTURAL ENGINEER DESIRES ENGAGEMENT as DESIGNER. Large and varied experience in design and construction of both steel and reinforced concrete structures. Would accept moderate salary.—Address, P2740, The Engineer Office. P2740 B

TECHNICAL ENGR. SALESMAN WISHES to GET IN TOUCH with SPECIALITY MANUFACTURER of standing who requires the services of an expert salesman. Good interviewer, tactful and with expert engineering training.—Address, P2741, The Engineer Office. P2741 B

WORKS MANAGER (29), Genl. Engineering works, B.Sc. Eng. (Lond.), organisation proved in greatly reduced costs, quick deliveries; 14 years' practical experience, incig. 9 years consulting, design. ing, estimating, DESIRES similar or technical responsible POST. Moderate salary, good prospects.—Address, P2738, The Engineer Office. P2738 B

WORKS MANAGER Shortly OPEN for ENGAGEMENT; thoroughly up to date in all duties, first-class organiser, successful record for running works on competitive and economical lines; highly experienced in wide range of general engineering; high-grade mass production and electrical work, together with iron and non-ferrous foundries; excellent references.—Address, P2744, The Engineer Office. P2744 B

YOUNG MECHANICAL ENGINEER, Public School education, with shop and drawing-office experience, SEEKS SITUATION.—GADSDON, "Fairfield," Hutton, Essex. P2722 B

ENGINEERING DRAUGHTSMAN DISENGAGED; 17 years' experience, 10 years mechanical with shop practice, 7 years structural, surveys, designs, estimates for steel work, also builders' work.—Address, P2737, The Engineer Office. P2737 B

MISCELLANEOUS

SPECIALIST in Accelerating Production in Engineer's and Machinist's Shops is PREPARED to MAKE SUGGESTIONS. Terms to suit circumstances.—Address, P2723, The Engineer Office. P2723 J

MACHINERY, &c., WANTED

WANTED, 4 RADIAL DRILLS of Good Make 6 to 7ft. arm. Must be in first-class working condition.—Address, 4667, The Engineer Office. 4667 F

For continuation of Small Advertisements see page 3.

A Seven-Day Journal

The Electrical Industry.

DURING the course of a recent lecture to the Metropolitan-Vickers College Apprentices' Association, consisting of over one hundred men selected from the principal universities at home and abroad, Sir Philip Nash said that in less than one hundred years over seven hundred and fifty million pounds had been invested in the electrical industry by this country alone, and at the present time practically every phase of modern life derived benefit from the use of electricity. As an instance of progress he mentioned that in 1880 the largest electric generator had a capacity of 60 kilowatts, whilst at the present time a single unit 60,000-kilowatt generator was at work and a 200,000-kilowatt machine had been designed. He anticipated that for this country alone over 30 million kilowatts capacity of turbines, generators, transformers, motors, and switchgear would be required as a result of the development expected to follow the new Electricity Act. Referring to the Metropolitan-Vickers Company, he said that more than half of the company's business came from abroad, and that much of the apparatus for export had to meet more onerous conditions than those met with in this country. He looked to the apprentices to fit themselves to play their part in maintaining the progress of the industry and he strongly advised them to develop the human side by studying very carefully their duty to each other and to the workmen.

The Engineer-in-Chief, L.M. and S. Railway.

IN view of the recent changes in the administration of the London, Midland and Scottish Railway, it is not surprising to learn that Mr. E. F. C. Trench, the engineer-in-chief, has resigned. He will, however, remain connected with the company as its consulting engineer. Mr. Trench comes of a well-known Irish family and graduated at Trinity College, Dublin. One of his earliest occupations in railway engineering was as a resident engineer on the construction of the Dore and Totley branch and of the widening of Alfreton Tunnel, both on the Midland Railway. In 1903 he succeeded Mr. Thomas Matthews as engineer of the North London Railway, and in 1906 went to Euston as assistant engineer to Mr. E. B. Thornhill, the then chief engineer of the London and North-Western, to whom he had originally been a pupil. In 1909 Mr. Thornhill retired and Mr. Trench succeeded him, and on the formation of the London, Midland and Scottish became the engineer-in-chief to the combined company. He has long been on the Council of the Institution of Civil Engineers and is one of its vice-presidents. One of his semi-public duties was to assist in reporting on the stability of St. Paul's Cathedral. Mr. Trench was a reporter on Track to the International Railway Congress of 1922 and presided over Section I. at the London Congress of 1925. The new chief engineer is Mr. Alexander Newlands, at present the divisional engineer at Crewe, whither he went in 1924 from the Highland section. Mr. Newlands joined the Highland Railway in 1892 and succeeded Mr. William Roberts as chief engineer in 1914. He is known as a very capable railway engineer.

Registration of Engineers.

AT a meeting of the Institution of Production Engineers on Thursday, January 27th, Mr. Richard Hazleton, secretary of the Society of Technical Engineers, explained the aims of the Bill for the registration of engineers, which is being introduced again in this session of Parliament—subject to good fortune in the matter of the members' ballot for Private Bills—and also the objects which the Society has in view. The Bill was formally introduced last session, although it was not anticipated that any progress would be made with it. On the general question of the desirability of registration for engineers as a means of improving their status and also protecting the public, Mr. Hazleton said he did not believe there is any difference of opinion among engineers, and he agreed that it is on the details of any measure for securing this end that a scheme of this nature is likely to meet with serious opposition. He reminded his audience that the Bill of the Institution of Civil Engineers, which was introduced about five years ago and was eventually withdrawn, practically provided that the Council of the Institution of Civil Engineers should be the registration authority, and it was because the other leading engineering institutions objected to this that the scheme failed. Discussing the reasons why a practically, unknown and admittedly new society like the Society of Technical Engineers should have introduced a Bill now, Mr. Hazleton said it was solely with the object of ensuring that some serious action should be taken in the matter. His Council was convinced, from the inquiries it had made, that on the general principle there was no opposition from the majority of engineers and the Bill as drafted contained merely tentative proposals for consideration by all concerned. It was the hope of his Council that the Engineering Joint Council would take the matter up in an authoritative manner, and in that event the Society of Technical Engineers would be only too pleased to hand it over. A communication had been sent to the Engineering Joint Council, which consisted of representatives of the leading engineering institutions, and he hoped that it would be discussed at the next meeting of that body.

A Rubber Exhibition.

THE International Exhibition of the Rubber Industry, which has just been held in the Grand Palais, Paris, was more remarkable for the interest and importance of the British participation than for the foreign exhibits, and it was so far from being purely a manifestation of the production and uses of rubber that Britain, France, Belgium, Portugal, and Holland had attractively arranged sections devoted to all kinds of colonial products. The enterprise of the British colonial administrations was observable in the manner in which they displayed the resources of Malaya and the Gold Coast. Machinery occupied far less importance than had been expected, and in the small space allotted to Germany the machines shown and the propaganda work carried out left no doubt that manufacturers in that country are making a strong bid for business in the mechanical equipment of rubber factories. Krupps made a special feature of rustless rolls. In the Dutch East Indies section Sanders-Birnie, of The Hague, exhibited a machine constructed by the Reineveld Engineering Works, of Delft, Holland, for rolling the freshly coagulated rubber latex by passing it through a multiple roll mill, and it is claimed that great economies are effected by the use of a machine which produces commercial sheets direct from the coagulated latex. This process is carried out on an endless band to prevent the sheet from being broken or torn. There was very little else in the way of rubber machinery, but oil presses and cotton ginning machinery were represented, Platt Brothers and Co., Ltd., of Oldham, showing their "Murray" air blast huller gin. The French machinery exhibits were also of small extent and consisted mainly of oil presses and rice conditioning machinery.

Another Low Temperature Test Report.

UNDER the scheme whereby at the public expense the Fuel Research Board is authorised to test plants for the low-temperature carbonisation of bituminous coal, four different types of plant have now been tested and reported upon. The latest report, just issued, relates to a "Freeman" multiple retort belonging to British Oil and Fuel Conservation, Ltd. The plant examined was erected at Willesden, but has since been dismantled. The first attempt to test it was a failure and the company's staff was unable to keep the plant working for the period necessary to obtain trustworthy results. A complete overhaul and certain alterations were necessary to secure a satisfactory set of test figures, and as the company was not in a position to carry out the alterations the Department leased the plant from the company for a few months at a nominal rent with full power to make such changes and tests as it considered desirable. The plant is of the externally heated type and is characterised by the fact that the coal during carbonisation is turned over and is not as usual in a state of comparative quiescence. The results of the tests, in some respects incomplete, show that the modified plant can carbonise up to 6 tons of bituminous low-caking coal per twenty-four hours. The type of coal carbonised is restricted to slack of a fairly low caking index, but the limiting index is not known. The plant gives a higher yield of dry tar at the normal working temperature of 500 deg. Cent. than any other which the Fuel Research staff has had under observation. The highest yield was 21·1 gallons per ton. The coke produced is in the form of a very combustible powder, which with further grinding might be used as a pulverised fuel or by briquetting it as a household fuel. Difficulties still exist in the modified plant, but it would appear that they are not regarded as insurmountable.

A Congo Quay Contract.

AN important contract for the construction of two reinforced concrete deep-water quays on the Congo for the Belgian Government has just been secured by a London firm of contractors, Perry and Co. (Bow), Ltd., who, for the purpose of this and similar contracts, have formed a Brussels company, Constructions Coloniales et Continentales. Messrs. Perry secured the contract in the face of keen competition and are responsible for the detailed designs and system of operations, which have been planned by them in conjunction with their consulting engineers, Messrs. A. J. Barry and Partners, of London. The contract provides for the construction of an entirely new port at Ango-Ango, a few miles below the existing port of Matadi, on the left bank of the river, and also for the enlargement of the existing port at Matadi. The new quay at Ango-Ango will have a length of 180 m., and the extension at Matadi a length of 340 m., while in each case a further length of pier is to be constructed, forming a link between quay and river bank, this section being at Ango-Ango 40 m. in length and at Matadi 80 m. In each case the construction is to be of reinforced concrete, with hollow steel piles, filled in with reinforced concrete below. The total estimate for the contract is nominally equivalent to £350,000, but it is anticipated that extensions of the specifications and currency adjustments will bring the total expenditure to a considerably higher figure. The materials and plant will be purchased partly in Belgium. The contract time at Matadi is estimated at three years three months, and that at Ango-Ango at two years three months. On filled ground behind the quays, warehouses, 100 m. by 40 m., are to be built on pile foundations, while provision has also to be made for railway communication between the quay front and the mainland at both ends at Matadi and at one end at Ango-Ango. The labour force to be employed will probably number about 1200 to 1500 natives, in addition to European engineers, supervisors and clerical staff.

Flooding the Gladstone Docks.

AT high tide on the morning of Tuesday, February 1st, the sluices in the west wall of the new entrance lock to the Gladstone docks at Liverpool were opened, and in a little over four hours on a falling tide the dock basins, aggregating some 55 acres, were flooded to a depth of a few inches. It is expected that the flow from at least fourteen tides will have to be utilised to fill the newly constructed docks to the required depth of about 48ft. The new entrance lock, through which the incoming water passes, is a basin of 1070ft. in length, with a width of 130ft. and a depth of over 60ft., which will allow the largest ships yet constructed to go in and out on every tide. The general level of the quays surrounding the new docks is about 63ft. above the clay bottom, and a quantity of water, calculated at 3,500,000 tons, or over 780 million gallons, will be required to bring up the level of the water in the docks to the required depth in the main Gladstone Dock and the Gladstone branch docks Nos. 1 and 2. A part of the main dock just opposite the gate of the Gladstone graving dock still remains to be excavated a further 15ft. to 20ft. in depth. The material to be removed consists of a shelf of clay and mud, and it is hoped that by running water into the docks, as has now been done, this mass will be so softened as to permit of its being removed by dredger instead of by the steam navvies which have been employed in making the main excavation.

Petters Limited.

THE fifth annual dinner of Petters, Ltd., which took place in the Town Hall at Yeovil on Saturday evening, January 29th, was an event of unusual interest, as for the first time the combined staffs of the Yeovil and Ipswich works were represented. The chair was taken by Mr. G. B. Petter, who welcomed the guests, and regretted the unavoidable absence of Sir Ernest Petter and Captain Petter. Mr. P. W. Petter, who this year is the Mayor of Yeovil, made an interesting reference to the importance of the undertaking of Petters Ltd., to the township of Yeovil. He believed that about one-quarter of the population of the town was directly dependent on the Westland Works, and perhaps half as many again were indirectly affected by their prosperity. The year just entered upon appeared to afford, he thought, reason for anticipating a greater volume of work on the engineering side of the business. In the absence of Sir Ernest Petter, he briefly referred to the firm's recent acquisition of the sole interest in the Ipswich works, which event was first announced in December last. The Ipswich works, which until that time were jointly owned by Vickers-Petters, were founded to develop the Petter oil engine some seven years ago, and it was fitting, he thought, that the parent business and the Ipswich factory should now be consolidated in one enterprise. Mr. Petter said that the two works were separated by a distance of about 200 miles, but they looked to the Westland Aircraft Works to assist them in bridging that gap by instituting a daily aeroplane service of, say, two hours' duration.

L.B. and S.C.R. Locomotive "Gladstone."

THE Council of the Stephenson Locomotive Society announces that negotiations for the preservation and acquisition of Mr. William Stroudley's celebrated express passenger locomotive Gladstone are now completed. Everyone interested in railway history will remember that this locomotive was the first of a class of thirty-six which made the name of its designer famous throughout the world. Built in 1882 and put to work in December of that year, the Gladstone has completed forty-four years' service. It has just been withdrawn by the Southern Railway in order to be restored to its original condition and repainted in the very distinctive yellow colour adopted by Mr. Stroudley. Arrangements have been made with the London and North-Eastern Railway for the Gladstone to be housed in the railway museum at York until such time as accommodation can be found in London, possibly at South Kensington Museum, in the course of a few years. The Stephenson Locomotive Society has made itself responsible for the cost of the work of restoring the engine, and has opened a fund to defray the somewhat heavy expenses. Donations to this fund may be sent to the Society's treasurer, Mr. F. H. Smith, 159, Albert-road, Croydon, Surrey.

The Reid-MacLeod Steam Turbine Locomotive.

AMONGST the attempts which are now being made to apply the steam turbine to locomotives, and thereby secure an efficiency comparable with that of power stations, the engine of the North British Locomotive Company, Ltd., constructed under the patents of Sir Hugh Reid and James MacLeod, deserves our special attention, if for no other reason because it is the only turbine locomotive in existence which is wholly British in invention, design and construction. But apart from that claim upon our sympathies, the locomotive is of exceptional interest because the problem has been attacked in a different way from that followed by other makers. Speaking quite broadly, the arrangement consists of a long girder frame on which the boiler, condenser, &c., are mounted, and which is borne by two eight-wheeled bogies. On one bogie is fitted a high-pressure steam turbine and on the other a low-pressure turbine. Each of these turbines drives through reducing gear a short longitudinal countershaft, which is provided at each end with a bevel pinion gearing with a large bevel wheel on a quill which, in turn, through the intermediary of the driving wheel, drives the axle passing through it. Thus, it will be seen that there are in all eight driving wheels but no coupling-rods, and complete balance is secured.

FIG. 1—THE REID-MACLEOD STEAM TURBINE LOCOMOTIVE

The general appearance of the locomotive is familar to all who visited the first Wembley Exhibition, where it was a striking object in the Palace of Engineering. It was on that occasion illustrated in our pages, but to-day, in order to make our description complete, we give in Fig. 1 a view of it from the condenser or leading end. We also give, as a Supplement, a general arrangement of the locomotive, and on the next and succeeding pages we reproduce a number of photographs of essential parts. Of the illustrations, Figs. 3 and 4 and Figs. 8 and 9, page 130, are perhaps the most instructive. In them can be seen the arrangement of the motive mechanism on both trucks, whilst Fig. 10 is a side view of the high-pressure unit, which shows very clearly the suspension and the driving ends of the quills. Fig. 11 is a view of the high-pressure bogie, complete with its four additional carrying wheels.

The engine runs, as already indicated, condenser first, with the chimney therefore at the hind end. The boiler occupies the greater part of this end, and right under it is the high-pressure bogie. The steam exhausted from this turbine passes through either of two pipes, ahead or reverse, to the low-pressure turbine, which, being right underneath, is able to deliver by a short path to the condenser. The diagram reproduced in Fig. 2 shows the flow of the steam and many of the details to which we shall refer later.

With these preliminary remarks, we may now examine the engine more closely. Beginning with the boiler, we note that it presents no exceptional features, being, in fact, of a standard superheater type. In substitution for the irregular blast on the reciprocating locomotive, a steady, forced or induced draught system is provided. A fan driven by a steam turbine is employed, and arrangements are made to deliver the air from the fan into the ash pan at a pressure of about 4½in. of water or to turn it up the chimney, so that an induced draught may be produced. The object of this dual arrangement is, of course, to prevent a blow-back of the flames on to the fireman when he opens the fire-door. The change from forced to induced draught is effected automatically in this way. There is fitted over the end of the fire-door latch a small quadrant. This quadrant locks the door, which cannot be opened until it is lowered. But lowering the quadrant shuts off the forced draught into the ash pan and opens a damper in the induced draught trunk. Thus the direction of the air is changed automatically, being always "forced" when the door is shut and "induced" when the door is open.

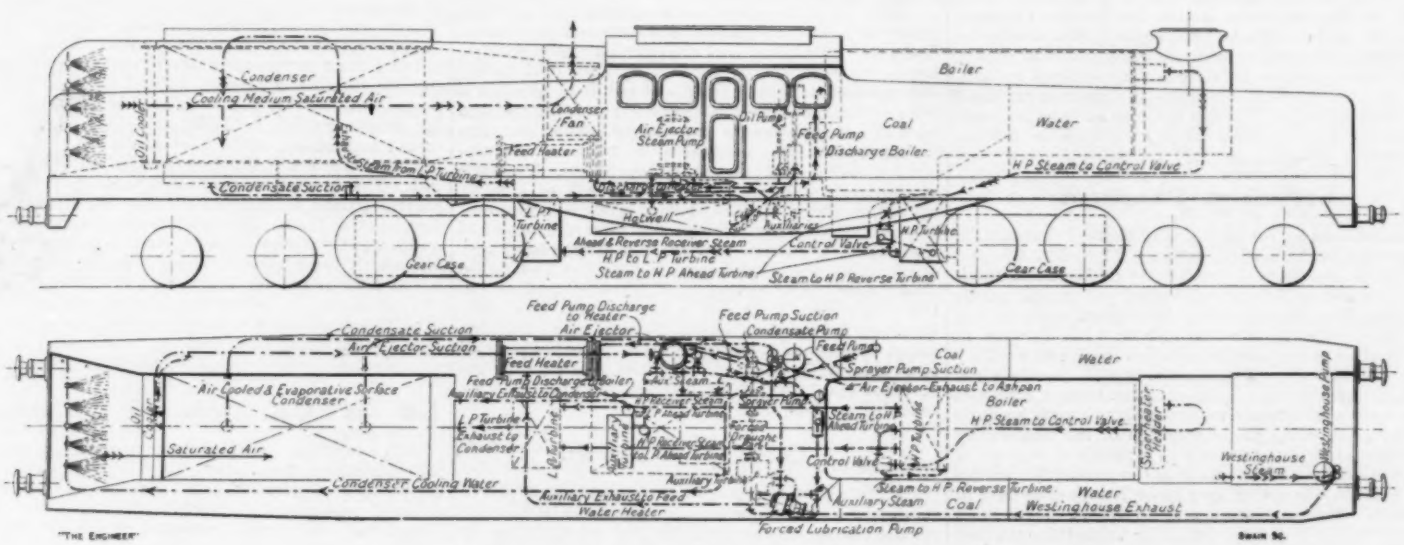


FIG. 2—DIAGRAM SHOWING FLOWS OF STEAM, WATER AND AIR

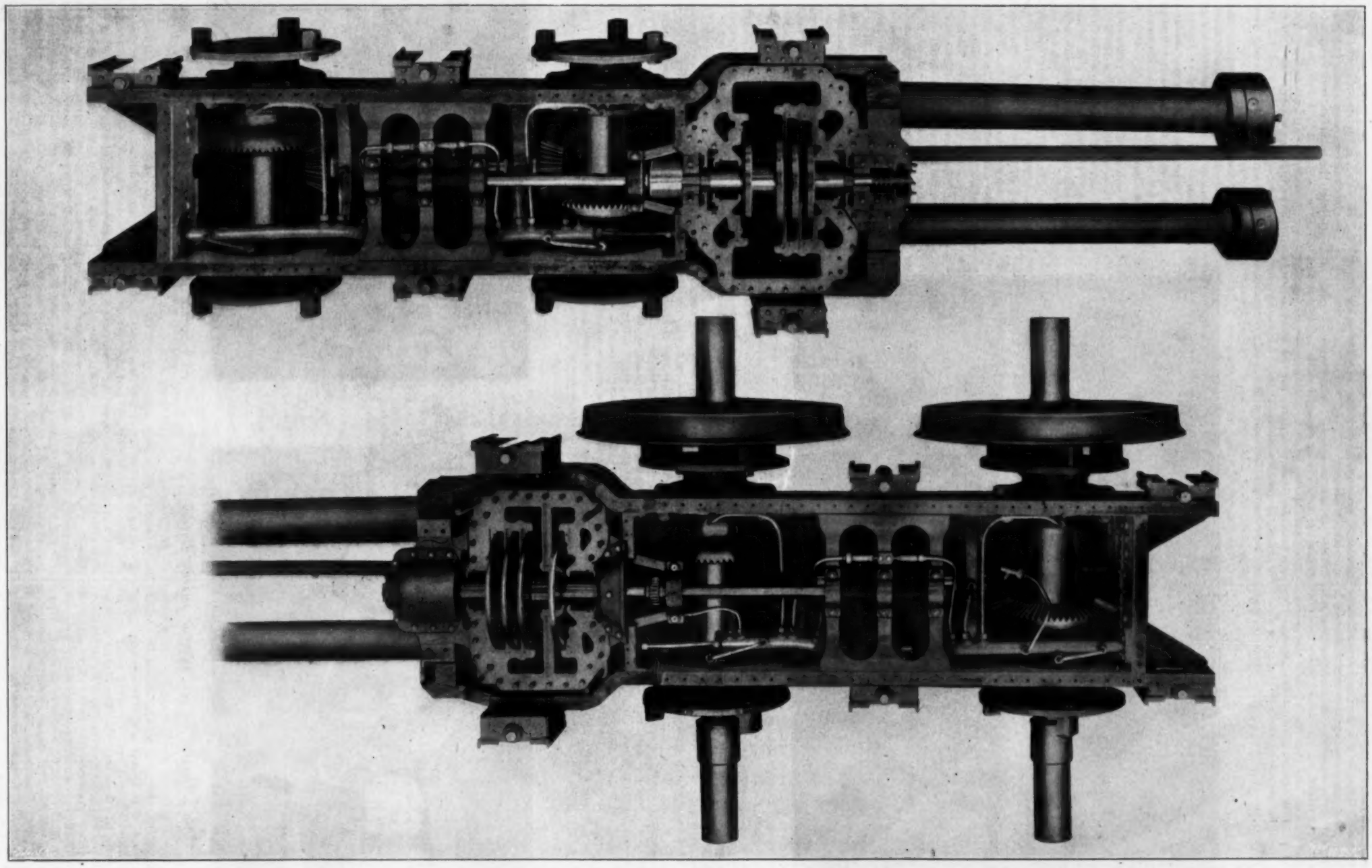
Steam from the boiler is delivered at a pressure of 180 lb. per square inch, through a control valve to the high-pressure turbine, the rotor of which is shown by Fig. 5. This, like the low-pressure turbine, is of the impulse type, and is capable of developing 500 H.P. at 8000 r.p.m., which corresponds to a running speed of 60 miles per hour. We may mention at once that the low-pressure turbine develops the same power and that a reversing turbine, giving 70 per cent. of the power of the ahead turbine, is incorporated in each casing. Reversal is carried out very simply, as we were able to satisfy ourselves by tests in the makers' sidings. On the left-hand side of the cab—Fig. 6—there is a column near the summit of which a vertical hand wheel is mounted. By turning this wheel in the ahead or reverse direction, the engine is controlled, both as to speed and direction. The ahead admission is effected through two 3in. double beat valves, one of which opens after the other, both being used when full steam admission is required. A single 4in. valve is employed for the reverse.

The steam leaving the high-pressure turbine passes through receiver pipes to the low-pressure turbine, and thence to the condenser, which is of the air-cooled evaporative type. The condenser comprises groups of flattened copper tubes, cylindrical at both ends, where they are expanded into top and bottom tube plates, to which corresponding headers are fitted. The tubes are divided into two main groups, the exhaust ascending the tubes in the first group, and descending those of the second group to the bottom header from which the condensate is withdrawn and discharged through the air pump intercooler to the hot well underneath the cab by a rotary pump. A turbine-driven fan draws air over the condenser tubes and at the same time water is delivered from a number of jets in a fine spray, which settles on the tubes and is at once evaporated by the steam, the moisture-laden air being drawn out by the fan already mentioned and discharged to atmosphere. The jets or vaporisers, as they are called, are controlled from the cab by a control which indicates the particular group or groups of vaporisers in operation. Owing to the fact that the engine travels with the condenser leading, there is a natural current of air through it, which greatly assists the fan. The non-condensable gases are withdrawn from the condenser by a two-stage steam ejector air pump, the heat in the steam being given to the condensate in an intercooler on its way to the hot well. As already stated, the condensate is withdrawn from the condenser by means of the condensate pump and discharged through the air pump intercooler to the hot well tank from which it is withdrawn by the boiler feed pump, and delivered to the boiler through a feed-water heater, which receives its supply of exhaust steam from the boiler feed, forced lubrication and Westinghouse pumps. The heater drains are returned to the hot well tank.

Having followed the steam in its course, and completed the boiler feed circuit, we may now return to the mechanism of the bogies, although the illustrations we give are so illuminating that little remains to be said. It will be seen that the high-speed pinion shaft in each case is provided with two helical pinions of opposite hand, which drive corresponding helical wheels. This arrangement, by providing four bearings, gives admirable support for the relatively light pinion shaft, which, we may add, is flexibly connected to the turbine shaft, as indicated in Fig. 7. The reduction effected in this gear is 8 to 1. On each end of the countershaft a bevel pinon is keyed, and as one pinion gears with a bevel wheel on the right of the engine and the other with a bevel wheel on the left of the engine, both of the latter have the same direction of rotation. The reduction ratio in these pairs

THE REID-MACLEOD STEAM TURBINE LOCOMOTIVE

THE NORTH BRITISH LOCOMOTIVE COMPANY, LTD., GLASGOW, ENGINEERS



FIGS. 3 AND 4—MOTIVE MECHANISM OF LOW-PRESSURE AND HIGH-PRESSURE BOGIES

is 2·38 to 1, so that the total reduction is approximately 19 to 1. The bevel wheels are keyed to quills, which are provided at each end with discs on which three blocks—see Fig. 7—are bolted. The axles pass through the quills and the wheels are driven in either direction through the intermediary of three helical springs in compression, spherically seated in the blocks already mentioned and corresponding projections on each wheel.

We need scarcely add that the whole of the gearing is enclosed in oil-tight casings. On reference to Fig. 10, it will be seen that the whole motive power unit is carried on six helical springs—three on each side—and arranged within guides. Thus the main driving machinery as a unit is flexibly controlled in a floating position free from displacement of the surrounding structure and wheels of the locomotive. As Fig. 11 shows, the axle-boxes are fitted with plate springs.

A continuous cooled stream of lubrication is supplied to all bearings and rotating parts of both main and auxiliary machinery, with the exception of the axle-boxes, by a steam-driven reciprocating pump.

The arrangements for handling the engine are exceptionally complete and convenient. The driver, as may be seen from Fig. 6, takes his place on the left side of the cab, with all the essential controls just in front of him, and a well-illuminated gauge panel is fitted where it can be readily seen, both by him and by the fireman. The dials taken in order from the top left hand give the following indications:—Stop valve pressure (175 lb.); lubrication oil pressure (20 lb.); condenser spray water pressure, (35 lb. to 50 lb.); H.P. receiver pressure, ahead (27in. of mercu y to 22 lb. back pressure); condenser vacuum (27in.); condenser air fan turbine, oil pressure (20 lb.); forced draught fan oil pressure (30 lb.); H.P. receiver, reverse (27in. to 37 lb. back pressure). In the centre is a pyrometer (700 deg. Fah.). The figures are those read by ourselves during our recent inspection and test of the engine. In Fig. 6 the view is, of course, towards the condenser, and the turbine seen upon a pedestal right in the centre drives the condenser fan, to which reference has already been made. Behind the brake hand wheel there are gauges which show condensate pump discharge pressure (5 lb.) and condenser air pump vacuum (27½in.).

The cab, as those who examined the engine at Wembley noted, is extremely roomy, capable indeed of accommodating eight or nine people comfortably, and provides ideal conditions for the operating staff in which to perform their duties. At the fireman's end there are all the usual adjuncts of a normal locomotive boiler with, on the left of the engine, a vertical lubricating pump, steam driven, and on the right, a vertical steam feed pump.

We had recently the pleasure of seeing the engine put through various tests of a rather limited kind, but we heard with pleasure that she is likely to be run at an early date in regular service. On reaching the engine shed we found steam up at 176 lb. pressure, with a vacuum of 27in. in the condenser. On moving the control wheel a short amount in the ahead direction, the locomotive drew slowly out of the shed and proceeded towards the siding points. She was run backwards and forwards several times before a clear road to the sidings was secured. On reaching the siding a goods train of 280 tons was coupled up. The rails were very greasy and the wheels slipped badly, but the engine drew the train steadily, and several trips to and fro of 300 to 400 yards were made. The wagons were then uncoupled, and manœuvring tests were executed, the engine being reversed by merely turning the control wheel in the desired direction and without stopping the turbines. The engine responded very sweetly to this control. It was then returned to the shed, and Mr. MacLeod demonstrated the sequence of operations when starting up. They are as follows:—

(1) Raise steam on boiler to 90 lb.

(2) Start up forced lubrication pump.

(3) Start up auxiliaries, turbine, driving, forced draught fan, condensate and condenser water sprayer pumps, which now enables the steam in the boiler to be rapidly raised to the working pressure.

(4) Open main steam boiler stop valve, which enables the saturated steam from the boiler to pass through the superheater to the main turbine control valves.

(5) Operate control valves, both ahead and reverse, passing steam through the main turbines for warming up.

(6) Open steam stop valve to second stage. Air ejector pump.

(7) Close main and auxiliary drains and open stop valves supplying steam to turbine glands, the vacuum in the main condenser will now register up to 20in.

(8) Start up condenser air circulating fan turbine.

(9) Open steam stop valve to first stage air ejector pump, when the vacuum in the main condenser will register 28in.

The locomotive is now in readiness for service.

The time taken to complete the cycle of operations after the steam has been raised is 7 minutes.

It may be of interest to give in conclusion a few figures relative to the locomotive and her estimated performance in service. Working passenger trains she should haul 225 tons behind the tender at a normal express speed of 60 miles per hour and an average speed of 50 miles per hour. The condensing water should amount to about 13 gallons per minute and the boiler feed make up to half a gallon per minute. The tractive effort of the engine, as found by tests on a dynamometer at Hyde Park Works—see our issue of November 28th, 1924—is about 15,000 lb. As regards the question of initial capital cost of the locomotive to economies effected, we understand from the builders that taking fifteen years' operation as a basis, they estimate that there should be a net saving of not less than the entire initial capital cost of the reciprocating locomotive, after allowing depreciation and the return of the initial capital difference between the turbine and reciprocating locomotives at 5 per cent. interest.

From this brief description it will be gathered that the Reid-MacLeod locomotive, as built by the North British Locomotive Company, Ltd., is an exceptionally interesting attempt to employ turbines for railway traction. Taken as a whole, it is simpler than most of the other turbine locomotives which have appeared during recent years. It is unquestionably a very straightforward design, and holds out sufficient prospects of presenting in its perfect form a type of engine that merits careful consideration and exhaustive trial. It will be observed that the locomotive described above is of dimensions and power sufficient to demonstrate fully the entire system, and it will be realised that from data already obtained, units required for particular services can be constructed by increasing the range of power from and including the boiler to the condenser. We have before now urged the great railway groups to regard the development of new types of locomotives as essential and very practical research work. It is scarcely fair to expect private manufacturers to carry on such work wholly unaided, and we feel that the country would have every reason to congratulate itself if the four railways would form a common fund to provide for exhaustive tests on locomotives—and other railway material—which, after preliminary inspection, held out prospects of eventual success. We must admit that one company has shown a very progressive spirit in this respect, but we still hold that it is to the interest of all and to the country as a whole that a united effort should be made. In other lands, notably Russia and Germany, questions of this kind are looked upon in a national spirit; a little of that spirit here in railway matters could do no harm.

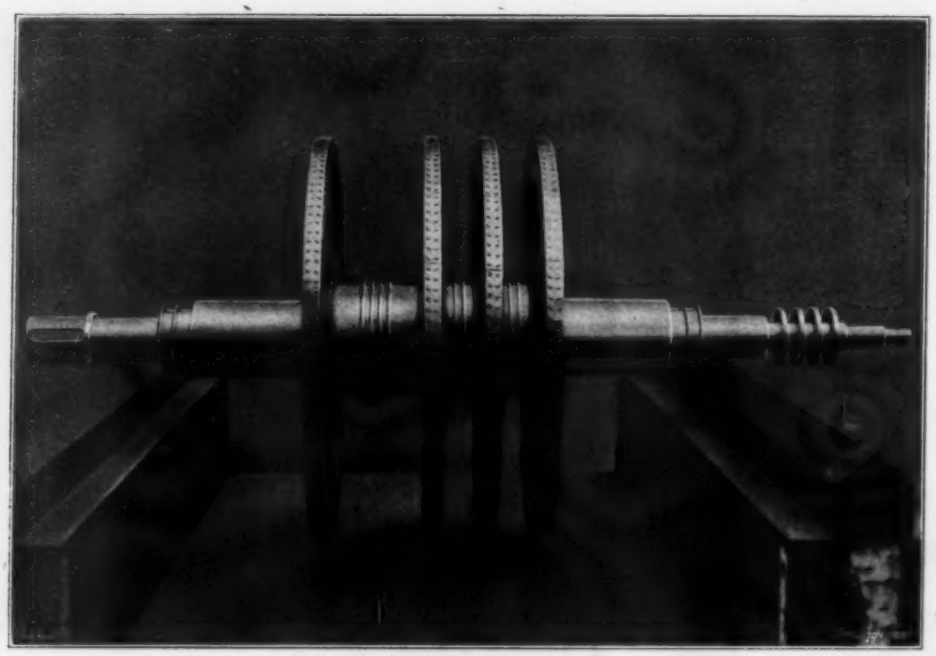


FIG. 5—ROTOR OF HIGH-PRESSURE TURBINE

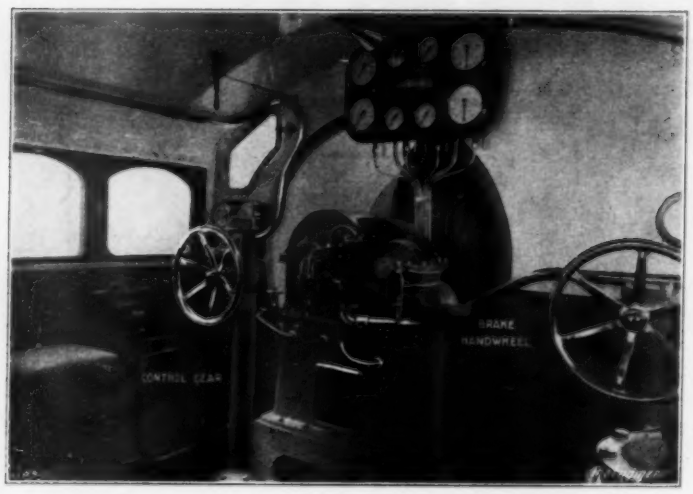


FIG. 6—INTERIOR OF CAB, SHOWING DRIVER'S CONTROL

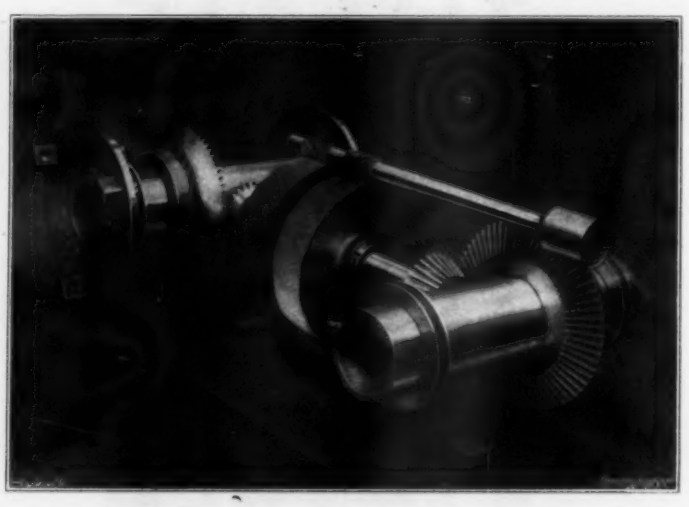


FIG. 7—DOUBLE REDUCTION GEARING WITH QUILL-DRIVE HOLLOW SHAFTS

Some Practical Notes on Soldering and Welding Aluminium.

By A. EYLES.

ALUMINIUM plays a very great *rôle* in modern life, and its importance is increasing daily. It is one of the most interesting of the commercial metals, being much valued for its extreme lightness, malleability and rustlessness. It has contributed considerably to the far-reaching developments in the aircraft, automobile, electrical, chemical and general engineering industries.

The ever-widening use of aluminium and aluminium alloys in the industries has brought with it the question of how to make repairs. In many cases a permanent repair can be made entirely satisfactory when correct methods are employed; but, unfortunately, there are too many incorrect methods employed to-day which make many craftsmen not only indifferent, but adverse to the repairing of fractured and defective aluminium products or components.

Since the jointing of aluminium and aluminium alloys is generally considered to be a difficult process, a few notes from one who has spent upwards of twenty years in research work, involving the investigation of various methods for making joints in the metal for the assembly of structures and the repairing of fractured or broken aluminium and aluminium alloy castings, should be of practical value and general interest.

The art of jointing most commercial metals has been known and practised for many centuries; but this is not the case with aluminium, as the use of this metal is only in its infancy, as compared with other industrial metals. Aluminium was obtained first in the year 1827 by F. Wöhler, but at that period it consisted merely of a light grey metallic powder, and it was not until the year 1845 that minute globules of aluminium were obtained. The process was developed further by H. St. Claire Deville, and put upon a commercial scale, with the result that over the period from 1845 to 1880 the price of aluminium was brought down from £23 to 28s. per pound. However, the jointing of aluminium was not accomplished until 1855, and it is only since the introduction of autogenous soldering or welding by oxy-acetylene methods that satisfactory progress has been achieved.

SOLDERING ALUMINIUM.

The question of soldering aluminium is a greatly debated subject, and possibly rightly so, because few craftsmen can make a permanently sound joint. It is well known to those accustomed in the art of soldering metals that there is no solder that acts with aluminium or its alloys, in the same way that ordinary soft solders operate with brass, copper, tin-plate, tinned, terne, or lead-coated steel sheets. Indeed, it is a mistake to speak of soldering aluminium—especially with relatively high-melting solders—as an ordinary tinsmith means soldering, *i.e.*, with a hot copper bit and a solder that will flow and follow it speedily. The process is more like brazing with hard solders—hence the need for a uniform nomenclature for variously termed methods in the jointing of metals. When this fact is once established in the mind of a skilled mechanic, he will have but little difficulty in joining or repairing fractured and broken aluminium parts provided he has the right grade of solder and efficient equipment.

Experience teaches that the degree of heat plays a considerable part in all forms of soldering operations, and the temperature required to make a strong and permanently sound joint varies with different metals, irrespective of the solder or flux used. In many cases failures in soldering aluminium can be traced to incorrect regulation of the heat used in making the joint.

Innumerable attempts have been made during recent years to discover a satisfactory solder for aluminium. Some idea of the time devoted in developing special solders for aluminium can be gained from examination of the patent specifications of inventions. During the last twenty years the author has tested many aluminium solders, and has made joints with them that were to all appearances quite satisfactory, and has been assured that the joints would retain their strength for an indefinite period. But in many instances these guarantees have not been fulfilled. On subjecting new joints to severe tests the metal was invariably broken ¼in. to ½in. away from the soldered joint, and it was extremely difficult to make a new soldered joint yield. But when the joints are exposed to moisture for a few months, the parting of the two pieces of aluminium at the soldered joint presented very little difficulty, thus proving that many of the so-called aluminium solders are not permanently satisfactory in a damp atmosphere unless protected against corrosion.

The following is a case in point, with reference to the disintegration of aluminium solders in the presence of moisture. Some few years ago the author made two aluminium vessels of triangular shape, 12in. deep, hard-rolled aluminium sheet No. 18 S.W.G. (0·048in.) being used. The seams or joints were made watertight by using a solder composed of 75 per cent. tin, zinc 7·5 per cent., aluminium 17 per cent., and (phosphorus 10 per cent.) phosphor-tin 0·5 per cent. One of the vessels was used for filtered drinking water in railway passenger car service, and the other for dry materials. Both were made at the same time and by precisely the same process. After a lapse of a few months the vessel that had been used for drinking water came back to the railway workshops for repairs, the defect being that the soldered seams were leaking. Upon examination it was found that the solder had badly disintegrated; in fact, the greater portion of it could easily be stripped off the aluminium, whereas in the other receptacle the solder is still in good condition. The author has several soldered specimens of aluminium, as well as aluminium soldered to brass, copper, terne steel and iron, that were jointed about twelve years ago. These are also in good condition, but it must be stated that the specimens referred to are not exposed to severe conditions, such as spray of sea water or a damp atmosphere.

The question of soldering aluminium has been discussed somewhat extensively in the United States Bureau of Standards Circular No. 78, Solders for Aluminium, and it may not be out of place to mention that the bibliography included an article on "Soldering and Brazing Aluminium," by the present author, published in *Machinery* (New York), December, 1914.

The composition of an aluminium solder may be varied within fairly wide limits. Most aluminium solders consist of a tin base, with the addition of aluminium and zinc, the chief function of which is to produce a solder that can be reduced to a semi-fluid condition within the range of soldering temperatures. Some aluminium solders contain copper, lead, bismuth, antimony, cadmium, nickel, silver, and other metals in addition, and in Germany several "hard" aluminium solders are used. These consist mainly of aluminium and have relatively high melting-points; in fact, the customary copper soldering bits are useless for jointing with these so-called solders, a blow-pipe flame being essential.

The author has been questioned many times during recent years as to the utility of these so-called "hard" aluminium solders, and the reply given is that they have little or no real value in industry, mainly owing to their relatively high melting-point—approximately 100 deg. Cent. (212 deg. Fah.) below that of aluminium, 658 deg. Cent.—and more particularly to the ease and reliability with which aluminium can be jointed by autogenous soldering or welding with the oxy-acetylene flame. Experience has shown that autogenous soldering or welding methods have the advantage over heterogeneous soldering methods of jointing aluminium, which invariably introduce alloys of a different position on the electro-chemical scale, setting up galvanic action and all the evils of electrolysis and subsequent corrosion.

The real need in the process of soldering aluminium is a low-melting solder which can be utilised with the same ease, rapidity and reliability as in soldering tin-plate, brass and copper, so that intricate products fabricated from aluminium could be jointed satisfactorily and speedily. Perhaps it is worth while briefly to mention the reasons why aluminium is troublesome to solder at soldering temperatures. (1) The formation of an almost imperceptible but very persistent oxide film, which prevents ordinary low-melting solders from alloying with the metal. (2) The highly electro-positive character of the metal causes galvanic action to be set up with most of the alloys in solder composition. Thus an apparently strong and sound joint may, owing to internal electrolysis, disintegrate within a comparatively short period. Especially is this the case in damp situations. (3) The thermal conductivity and high specific heat of aluminium renders local heating to the alloying temperature a tedious operation; more particularly as the size of the article worked on increases. Thus the heat is conveyed from the soldering tool and solder so rapidly that they become chilled quickly, and therefore the solder does not become sufficiently liquid to flow readily.

In soldering other metals the oxide can be removed chemically. With aluminium, in the absence of an efficient soldering flux, the oxide is best removed mechanically by abrasion.

Experience gained during the past twenty years proves that the low-melting solders are best applied without a flux after preliminary cleaning and tinning of the surfaces to be soldered.

The fundamental operation preparatory to soldering is thoroughly tinning the surfaces to be joined. The process of tinning is best accomplished by heating the areas to be soldered to a temperature somewhat above the melting point of the solder used. A satisfactory tinned surface may be obtained by rubbing with the point of a clean steel tool, so as to remove the oxide film and allow the solder to operate on the clean surface. After the surfaces to be joined are properly tinned, they can readily be soldered together by pressing the tinned areas in contact, again heating the metal and solder to the desired temperature, and finally by rubbing throughly with a tinned—correctly heated—soldering tool the surfaces carrying the liquid solder. The best method of working is to use an atmospheric blow-pipe or blow-lamp flame to heat up and play on the metal during the soldering operation. The flame, however, must be free from free carbon.

Obviously, as will be gathered from the foregoing, aluminium can be soldered, but it is not advisable to employ soldering methods, strictly speaking, for the assembly of structures; hence, its only actually feasible applications are for repairing fractured or broken parts, and for filling up surface holes and slight defects in castings, so that they will have a good appearance.

Finally, solder of any kind should not be applied on stressed members or on any components, the failure of which might be serious.

THE WELDING OF ALUMINIUM.

Much has been written during the last decade regarding various electric welding systems, and their spheres of applicability, but in the art of welding aluminium the best results, both in production and repair work, have invariably been obtained by employing oxy-acetylene methods. With most other commercial metals electric welding is perhaps more effective, whereas the heat of the acetylene flame is applied entirely from the outside. When work is suitable for electric welding, welds can be made with much greater rapidity than by the oxy-acetylene method of welding, but that cannot be said with regard to the welding of aluminium or even aluminium alloys.

If we were to turn back a score of years we should find that the welding of aluminium suffered unnecessarily from secrecy. Fortunately, there is little in the process that is kept secret to-day, although it requires skill and training, together with knowledge how to apply the system and to design and prepare the work, as well as to make the welds. But when the technique of welding aluminium has been thoroughly mastered, aluminium is one of the most readily weldable of all metals.

The credit of having first welded aluminium appears to be due to the invention of W. C. Heraeus, Hanau, near Frankfurt. The firm of Messrs. Heraeus exhibited at the Paris Exhibition in 1900 a collection of wires, rods, sheet vessels, &c., with welded joints. The process is described as follows in the *Electro-Chemist and Metallurgist*, March, 1901:—"The operation consists in cleaning the surfaces to be joined, laying them together and heating carefully to the temperature at which the metal commences to soften, keeping at that temperature, and meanwhile hammering together to a perfect weld. It is important that the temperature be kept constant; if the metal rises too high, the metal becomes short or granular, and commences to oxidise—a condition which renders the weld useless." Not only is the process of interest from a historical view point, but also from the fact that it is a form of true welding. The limitations of the process, however, in the fabrication of aluminium products are obvious, and it has been entirely superseded by oxy-acetylene welding methods.

Until the method of jointing by autogenous welding was perfected, the use of aluminium, especially in the assembly of structures and the fabrication of sheet metal articles, was more or less restricted to those cases in which jointing was either unnecessary or of no great importance; but the process of welding aluminium with the oxy-acetylene flame has been taken advantage of in the automobile, aircraft, chemical and general engineering industries to an extensive degree, and as a result aluminium has not only supplanted other metals, but also various other materials in many branches of modern industry.

The welding of aluminium joints, obviously makes a much stronger and more intimate union than soft or so-called "hard" solders, there being no interposition of any heterogeneous metal.

The special difficulties in welding aluminium are—the rapid formation of a refractory oxide film on the surface of the metal; its high rate of expansion and contraction, being approximately twice that of steel; its high thermal conductivity; its high specific heat, being 0·212, which is more than twice that of copper; its relatively low fusion point; its comparative weakness in tension, especially at high temperatures and in welding, particularly aluminium alloy castings; the chances of distortion or warping makes it somewhat difficult to keep the work in alignment.

In the assembly of welded structural work, the phenomena of expansion and contraction become of very great importance, since with aluminium their effects are more marked than in iron or steel. Hence the necessity for care when designing aluminium structures and joints for autogenous welding, so as to avoid as far as possible the internal strains set up by expansion and contraction.

It is impossible to achieve the maximum advantages of welded construction unless the original design contemplated the use of this modern method of making joints in aluminium. It is the lethargic engineer who takes a design developed by cut-and-try experience with riveted construction and merely substitutes welding at the joints.

The author some few years ago assisted in the construction of a large number of all-metal electric railway passenger cars, 63ft. 4½in. long, 12ft. 4½in. in height. The roof plates and panels consisted entirely of aluminium sheets, Nos. 14 and 16 S.W.G. (0·080in. and 0·064in.). Various views of these railway vehicles were illustrated in the Supplement to THE ENGINEER, February 25th, 1916. In the original design of the all-metal cars, the roof joints were to be autogenously welded with the oxy-acetylene flame, but one vehicle roof only was welded at

the joints. The internal strains set up during the operation of welding were not only sufficient to crack the metal at the welded joints, but distortion of the aluminium roof plates was very great. Obviously, the design of the work was unsuitable for the oxy-acetylene method of welding. Riveted construction—as shown in THE ENGINEER illustrations previously referred to—was the method subsequently adopted.

The two distinct methods used in welding aluminium are the so-called puddling system and the flux system. The puddling is done almost entirely without flux, using steel tools to remove or break up the oxide film, thereby allowing the metal to coalesce. These tools are usually made of $\frac{1}{8}$in. or $\frac{1}{4}$in. rods. One is pointed and curved slightly, and the other is flattened at the end like a paddle.

When puddling methods are employed there is a possibility that some oxide which has a higher specific gravity than the metal will remain in the welded joints, interfering with their strength, and will lead in time to disintegration. In other words, a welded joint in aluminium without a flux never presents perfect homogeneity. However, in many cases sufficient strength can be obtained, particularly in automobile gear, crank and sump cases, without the use of a flux; but even then a good flux will be found beneficial, for it will attack the oxide film almost instantaneously.

WELDING FLUXES.

In modern welding practice it is known that the principal function of an aluminium welding flux is to dissolve and deoxidise the layer of aluminium oxide adjacent to the joint to be welded. Since the melting point of aluminium is 658 deg. Cent., and that of its oxide approximately 3000 deg. Cent., it is possible to melt the aluminium without melting the oxide, and in welding the oxide is very difficult to disperse. In Fig. 1 is shown the existence of fluid or molten aluminium contained in a bag of oxide. The metal, having liquefied, has caused the flexible bag of oxide to sag. In order to demonstrate the existence of aluminium oxide more or less in the form it would be included in welds, the oxide has been pierced and the molten aluminium is seen running out. That is the oxide which was almost imperceptible and very persistent in both soft soldering and welding of aluminium. In welding aluminium with the oxy-acetylene flame, it is desirable to use a good flux—cheap "cure-all" fluxes are especially to be avoided—as its requirements are not only to dissolve and deoxidise the oxide formed, but also to protect the metal from further oxidisation during the welding operation. Aluminium welding fluxes now employed extensively with very satisfactory results, consist of various combinations of alkaline chlorides, fluorides, bisulphates, &c. They are usually in the form of a very fine powder; are very hygroscopic and deteriorate by absorption of moisture when exposed to the atmosphere; they should therefore be kept, when not in actual use, in air-tight containers. In this respect H. V. A. Briscoe and Captain D. Richardson have made an improvement whereby the use of an alkali pyrosulphate or pyrophosphate in the flux mixture prevents the dissociation of the components and hence provides a flux which may be stored for some considerable time without deterioration. A good flux with a melting-point of about 600 deg. Cent., may be made from a mixture of sodium and potassium chlorides, together with lithium chloride, potassium fluoride, and potassium bisulphate. The reactions which take place in fluxing aluminium are, it is thought, as follows:—

The potassium fluoride reacts with the potassium hydrogen sulphate, forming hydrofluoric acid, which immediately acts on the aluminium oxide, forming aluminium fluoride, which is free to combine with the excess of potassium fluoride existing in the flux to form potassium aluminium fluoride, and this is capable of dissolving a further quantity of aluminium oxide. The lithium and potassium chlorides added serve the purpose of lowering the fusion point of the mixture. Another point of view is that the potassium bisulphate may act partially alone, for on heating this salt to a temperature higher than its melting point it forms pyrosulphate, and on further heating breaks up into potassium sulphate and sulphur trioxide. Since this decomposition takes place at about 600 deg. Cent., it can be understood how the bisulphate will decompose substances like cryolite and calcium fluoride at a lower temperature than that required to fuse the mineral or salt itself.

Aluminium welding fluxes should be used sparingly and therefore should not be thrown on the weld in excess as the coppersmith or brazier does when brazing copper or brass. The best method is to use them in the form of a varnish on the welding material. The latter may consist of wire, rod or strip material, the end of which is heated and dipped into the flux, which readily adheres to it.

A good method of applying flux where welding wire, rod or strip is not used, is to paint a paste of the flux along the flanged edges of thin sheet material, and allow it to dry. Liquid or pasty fluxes can be reduced to proper consistency by mixing with water. It should be unnecessary to apply any additional flux, for the gradual melting up of the rod as the weld proceeds will automatically feed flux on the weld joint just where it is required and at a uniform rate. In other words, the flux will flow ahead of the welding flame and prepare the metal.

FIG. 1

WELDING MATERIAL.

For sheet or plate aluminium welding the filling-in material should consist preferably of a rod or wire of pure aluminium, for working on aluminium alloys the filling-in material should be of the same composition as the alloys to be welded. Unfortunately, the welding operator is often in doubt as to the exact composition of the alloy to be welded, consequently many operators use pure aluminium welding rods—a practice not to be recommended. Obviously, when pure aluminium rod or wire is used, the weld zone will be softer and more flexible than the alloy material, and constitute a defect that should be avoided, especially in the case of automobile aluminium alloy castings where considerable strength is required to enable them to withstand road shocks and excessive vibration. Similarly, aluminium alloy rods are not suitable for welding aluminium sheet or pure aluminium sections. A truly homogeneous weld in these materials is essential.

Welding wire and rods should be of a diameter slightly greater than the thickness of the metal to be welded. The minimum size of wire commonly used is about $^{3}/_{32}$in. in diameter, while even for thick sections rods over $\frac{1}{4}$in. in diameter are rarely used.

Should the welder find himself without the usual welding wire or rods when welding aluminium, or if the diameters are unsuitable for the work in hand, strips of sheet aluminium of similar sectional area may be used satisfactorily. Obviously, the width of the strips should vary according to the thickness of the aluminium to be welded, *e.g.*, the width should be approximately twice the thickness of the metal up to $\frac{1}{4}$in. thick, and one and a-half times the thickness for between $\frac{1}{4}$in. and $\frac{1}{2}$in. thick. If suitable folding or bending machines are available, the strips can readily be bent or formed somewhat like a welding rod, and are then more easily handled.

PREPARATION OF METAL FOR WELDING.

Proper and thorough preparation of the metal to be welded has an important bearing, both on the quality of the weld and the total cost of the seam or joint. The welder should remember that any aluminium job to be welded must therefore be properly cleaned and the parts lined up, held rigidly in place, &c., before any attempt is made to commence actual welding.

In production welding and repair work, various jigs and fixtures can be devised. The judicious use of jigs, often of the simplest design, invariably makes it possible to overcome distortion in the finished products, reduce the cost by increasing the speed of welding, and, in aluminium production work, assures standardisation. In other words, a better-looking piece of finished work is turned out when jigs are used to hold parts in alignment and to eliminate distortion.

Thin aluminium sheets, up to, say, a maximum of $\frac{1}{16}$in. thick, may have their edges flanged to an angle of 90 deg., as shown in Fig. 2, the flanges having a height of about one and a-half times the thickness of the metal. With this method, the customary welding wire or rod is unnecessary, the edges being fused and providing the necessary material for the weld. The two lower flanged edges should be adjusted so that they touch exactly. By the flange weld method it will clearly be seen that heterogeneous metal does not enter the weld joint, the latter being entirely composed of metal identical with the surfaces to be welded. When aluminium sections or sheets are from $\frac{1}{16}$in. to $\frac{1}{4}$in. in thickness, the edges may be simply butted together, as shown in Fig. 3. Above $\frac{1}{4}$in. in thickness, the angle of bevel at the weld should be about 90 deg., both edges being bevelled to an angle of 45 deg., as shown in Fig. 4, to enable the welding flame to come in contact with the whole of the surfaces to be joined. Aluminium sections of certain thicknesses are preferably welded from both sides.

In the case of cracks on thick sections that do not penetrate through the entire thickness of the metal, the bevelling should extend right to the bottom of the crack, as shown in Fig. 5, and the bottom must be thoroughly cleaned out with suitable tools to remove the last trace of impurities.

EXECUTION OF WELDS IN ALUMINIUM.

In the actual operation of welding the blow-pipe flame must be carefully regulated, and the correct adjustment of the gases maintained. The proper adjustment is secured with a slight excess of acetylene, although the neutral flame can be used satisfactorily. The smallest excess of oxygen in the welding flame should be carefully avoided otherwise the metal is rapidly oxidised. The white cone of the flame should never come into contact with the metal, because the high temperature of this part of the flame tends to produce holes in the metal, particularly thin sheet sections, which are by no means readily mended. The distance of the tip of the white cone from the surface of the metal will depend upon the power of the blow-pipe and the thickness of the metal, and will vary between $\frac{1}{16}$in. and $\frac{1}{4}$in. The blow-pipe should be inclined at a suitable angle from the plane of the weld—from 45 deg. to 60 deg.—and its motion should be away from the welding operator.

On aluminium $\frac{1}{8}$in. or more in thickness, one end of the filling rod should be constantly submerged in the molten metal in the welding groove. On no account must globules from the welding rod fall on the surface of the work. Sheet aluminium welds should be expeditiously executed from the moment the first fusion is obtained. A competent aluminium welder displays his skill in the manipulation of the welding flame at the right moment when fusion has proceeded so far that complete welding is assured; the dexterity in preventing the deformation of the metal under the heat of the welding flame, and the rapidity and ease of the operation.

After the work is completed the welded joint and the surrounding metal must be thoroughly cleaned by washing and brushing with hot water to remove all traces of the flux, thereby preventing subsequent corrosion of the metal. In some plants the welds are washed with a 5 to 10 per cent. solution of sulphuric acid to remove any chemicals left behind from the flux, afterwards, washing the work with warm water to remove the acid. It is obviously desirable that all traces of the flux should be removed after the welding operation. The author has seen several cases of injury to the surface of aluminium work caused by incomplete removal of the remains of the flux; although it took some time for the damage to develop. Although apparently so small a point, it has been

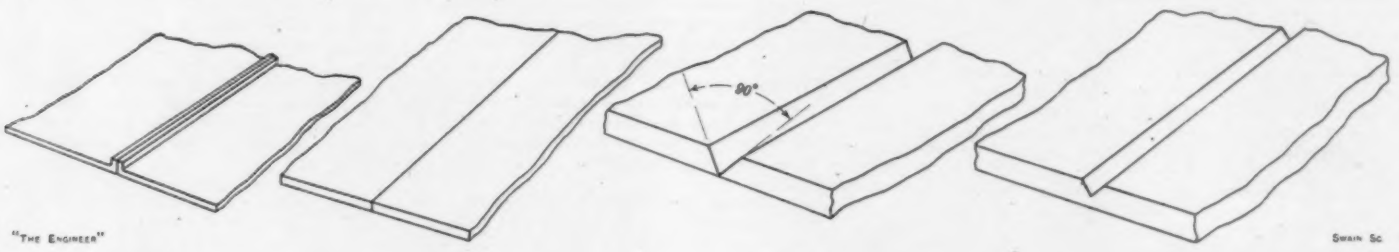


FIG. 2 FIG. 3 FIG. 4 FIG. 5

thought well to lay stress upon it. Lightly hammering in the cold over the area of the weld is very beneficial and should always be done where possible. In the welded state the metal has a coarse crystalline structure, but under cold work the crystals become elongated and give texture and grain to the welded area.

Sound aluminium welds possess a degree of strength practically equal to that of the original section, and the welds or joints present a neat and finished appearance, are homogeneous in structure, and from every standpoint they are of a very satisfactory character.

It will be gathered from the foregoing that sound and homogeneous welds are thus readily obtained in aluminium and aluminium alloys by those having adequate knowledge of how to employ the process of autogenous welding with oxy-acetylene methods correctly. When employed on aluminium products, the oxy-acetylene method is not only quick, but enables the operator to weld where it would be extremely difficult or impossible to work by any other method. There are also the additional advantages of simplicity, strength and economy.

Coilers for Cold Strip Rolling Mills.

By C. E. DAVIES, A.M.I. Mech. E., M. Inst. Met.

No. II.

ALL coiling devices hitherto described, excepting the last, are suitable for rolling speeds not exceeding 100ft. per minute; at that speed the operator has time to enter the strip into the drum without danger

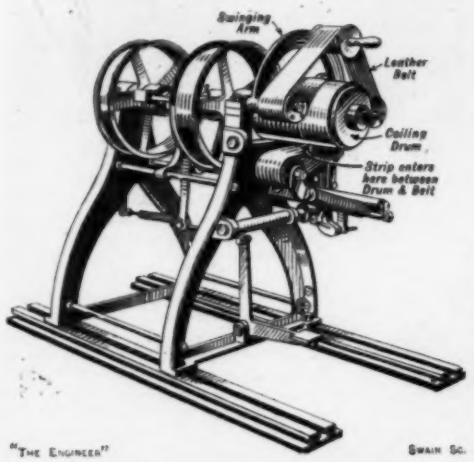


FIG. 13—AMERICAN AUTOMATIC COILER

of accident, but with the higher rolling speeds of 200ft. to 250ft. per minute, which are quite common in America, some automatic coiling equipment becomes a necessity.

The general principle of an automatic coiler is that the metal is led, by means of suitable guides, direct from the rolls to the coiler drum without handling, and the necessity of inserting the end of the strip at the start of the coil into the drum or spindle slot by hand is eliminated. To attain this end, the coiler must be brought as close to the rolls as possible, consequently an arrangement shown in its simplest form—in Fig. 12, *ante*—is desirable. Furthermore, some means must be provided to lead the metal from the mill rolls directly to the drum, to guide it round the drum so that the strip is automatically wrapped two or three times round the drum circumference; once that is accomplished a sufficient grip on the drum is obtained, and there is no tendency to slip even with the heaviest tension.

All such automatic coiling equipment is practically of American origin, owing to the general practice in that country of rolling at high speeds. The details of all the designs for automatic coiling would occupy too much space to describe fully, and it will be sufficient to outline the leading features of the best modern practice. Fig. 13 illustrates an example of one class of automatic coiler, in which the strip is guided from the mill rolls to the coiler drum, and is wrapped round the latter, without handling by the operator, by means of an endless leather belt. This belt is in contact with the drum for about three-quarters of its circumference, and is driven by friction at the circumferential speed of the drum; it is carried over four idle pulleys, the upper group of three being mounted on a hinged arm, so that the belt can be swung clear of the drum when removing coiled metal. The strip enters at the bottom of the drum between the drum and the belt. The machine shown is of American design and manufacture, and is arranged for belt drive; two driving pulleys being fitted, for open and crossed belts, with disengaging clutches, so that the drum may be reversed, to loosen the coil and facilitate its removal.

A similar coiling guide, operating by means of a leather belt, was used in conjunction with the simple coiling spindle on the high-speed mill—shown in Fig. 12, *ante*. In that case a loose wooden or metal drum is used, and is mounted on square end cut on the coiling spindle. The drum and coil are removed together on completion of the wind.

Another form of automatic coiling guide is explained by diagram Fig. 14. In this, the use of the leather belt is dispensed with, and the guide is entirely of metal construction. Two hinged jaws encircle the winding drum, and carry rollers which, pressing on the drum, are rotated thereby. The metal enters between guides in the direction shown by the arrow, and is immediately nipped between the rollers and the drum surface; the smooth interior surface of the jaws guides the metal round the drum circumference until a sufficient number of turns are wound on, and the friction between the strip and the drum is capable of providing the necessary coiling tension; as the coil grows in diameter with the winding of successive layers the jaws automatically open. This construction represents the latest practice, and is also of American origin, being designed and constructed by the Torrington Manufacturing Company, of Torrington, Connecticut, U.S.A. An application of this apparatus to a high-speed strip rolling mill is shown by Fig. 15. This mill, with automatic coiler, was built by W. H. A. Robertson and Co., Ltd., the coiling equipment being constructed to designs furnished by the Torrington Manufacturing Company. A full description of this plant was given in an article on the "High-speed Cold Rolling Mill" in THE ENGINEER of December 25th, 1925, and it is sufficient here to mention only the leading features of the design. The mill rolls are 300 mm. diameter (11·8in.), 350 mm. (13·8in.) face, and are driven at a speed of 60 revolutions per minute, giving a rolling speed of 56½ metres per minute—185ft. per minute.

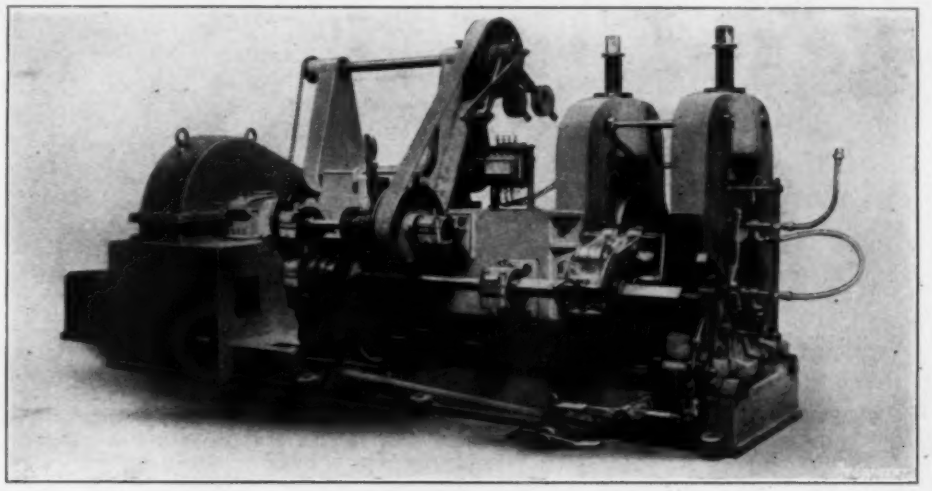


FIG. 15—TORRINGTON COILER APPLIED TO ROLLING MILL

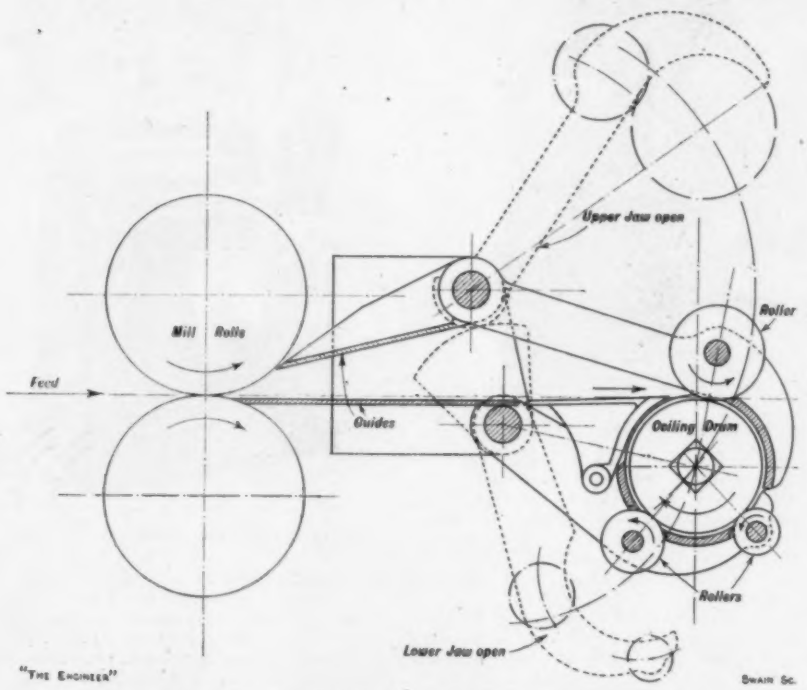


FIG. 14—DIAGRAM OF MECHANISM OF TORRINGTON AUTOMATIC COILER

The coiler mechanism, with which these notes are chiefly concerned, consists in outline of a heavy coiling spindle, driven through chain gear and belt from the mill driving shaft. The driven belt pulley contains a friction clutch of the multiple plate type by means of which the coiling tension is regulated. Machine cut spur gears, with a disengaging clutch of the toothed type, provide for reversal of the coiling spindle in order to loosen the finished coils. A loose wooden or metal drum is mounted on a square portion of the coiling spindle, the outer end of which is supported during coiling by an outer bearing, which is automatically swung aside to permit removal of the drum and coil. Pedal control is provided for stopping, starting and reversing the coiling spindle, the control gear being interlocked with the mechanism for swinging away the outer bearing mentioned above.

The automatic guide is also seen, and is on the principle illustrated by Fig. 14, and already described. With this equipment there is no difficulty in handling coils from the mill at the rate of two per minute. The tension can be adjusted within fine limits to suit the gauge of metal rolled, and it is possible to apply such a tension as will tear asunder a hard brass strip 8in. wide and $^1/_{32}$in. thick.

As will be understood, a coiler of this description, especially the automatic guide portion, requires to be constructed and fitted with the greatest accuracy, but, when once fitted and adjusted, it will give continued services without skilled attention.

A further development is the double coiler also of the Torrington Company's design. It includes two coiling spindles, which are used alternately. They are mounted on a capstan head, which is revolved by a control pedal, to bring first one and then the other into position to receive the metal strip. By this means a finished coil can be removed from one spindle while the other is actually winding the next coil, with the result that there is no time lost and rolling is practically continuous. It is scarcely necessary to mention that such powerful and elaborate coiling devices are comparatively expensive, but the advantages obtained by rolling at a speed of about three times that usual in English mills and obtaining a rolling efficiency $\frac{\text{(Actual Rolling Time)}}{\text{(Total Running Time)}}$ of about 90 per cent. easily repay the initial capital expenditure.

All the coiling machines considered so far are for dealing with comparatively thin strip metal, that is,

* No. I. appeared January 28th.

strip which can easily be wound on a drum of moderate size. Roughly, the maximum thickness for such coilers may be fixed at ·080in., or 14 S.W.G., and for strip, appreciably thicker than that, or even in some harder metals for gauges exceeding 16 S.W.G. (·064), it is necessary to employ coiling devices working on an entirely different principle.

THICK STRIP COILERS.

It is clear that the coiling of thick metal strip is not so necessary as it is for lighter gauges. First, because, with moderate weight of ingot or single piece of metal, the total length of the rolled strip is limited, and either the metal can be roughly coiled by hand, if the thickness is not too great, or can be left in straight length, if too heavy to be easily bent. Secondly, because a coiling tension is not essential, as in the case of thin metal, to remove "buckles," &c.

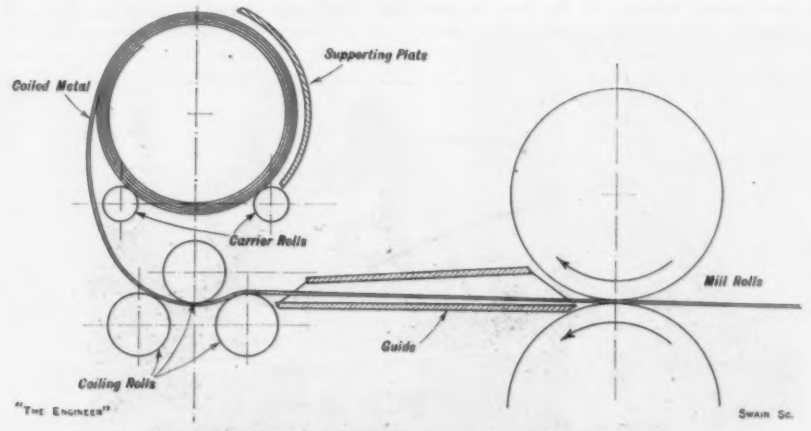


FIG. 16—DIAGRAM OF MECHANISM FOR COILING THICK STRIP

At the same time the practice is becoming more and more general every day to coil rolled strip as soon as the length is sufficient and up to any thickness which can be handled. Certainly the majority of cold rolling mills in this country still run out metal from the rolls in the earlier passes, in straight lengths, and although at first sight coiling in such cases would not appear to offer any great advantages, there are many reasons to support and emphasise the importance of coiling at as early a stage in the series of reductions as is possible. Take, for example, the cold rolling of brass strip, and the same remarks apply equally to many other metals. The rolling operation starts with a case ingot or slab, averaging 1½in. thick and about 2ft. 6in. long. The first seven or eight passes reduce this slab to a thickness of about ·2in., and its length will then be about 16ft. Now, whilst this length is not sufficient to render it very inconvenient to deliver it from the rolls on to the mill floor in a straight length, it is obvious that a great quantity of metal in this form occupies an excessive amount of valuable floor space and seriously interferes with the passage of material and workers through the mill. In addition, annealing is necessary at about this stage, and a furnace chamber somewhat greater in length than the strips must be provided, or even if roughly bent double by hand, unnecessary labour is involved and still a fairly long furnace is required. This consideration is of still greater importance after the next series of reductions, when the metal is reduced to about ·1in. thick and is over 30ft. long; annealing is again necessary, and the strip must be doubled even to get the lengths into a furnace, say, 18ft. long. The practice of annealing metal in this way has been the cause of one of the most serious troubles in the rolling of strip metal already mentioned, viz., the unequal annealing throughout the length, as it is practically impossible to insure a uniform temperature throughout such a long furnace chamber. Coiling offers a simple remedy for both these troubles, and the economy and superior results obtained by loading annealing furnaces with metal in the form of compact coils is too obvious to need further explanation. But coiling on a drum winder is impossible with metal as thick as ·2in. and even half that thickness. It is therefore necessary to introduce a special class of coiler capable of dealing with these heavy gauges. These coilers for thick metal work on the principle of the ordinary three roll bending machine—as illustrated diagramatically by Fig. 16. The strip passing from the mill rolls between one upper and two lower rolls, the upper roll being adjusted vertically, thereby bending the strip into a circle of greater or less diameter, according to the distance the upper roll is lowered betwen the two lower rolls. All roll type coilers in use operate on this principle, and are very successful in dealing with the heaviest gauges. The rolls should be as small in diameter as possible, consistent with sufficient strength, and in the best modern machines are made from a nickel steel having a high tensile strength. All three main rolls should be positively driven, as also the guide or carrier rolls which support the finished coil—as shown in Fig. 16. A supporting plate is also provided to hold the coiled metal in position.

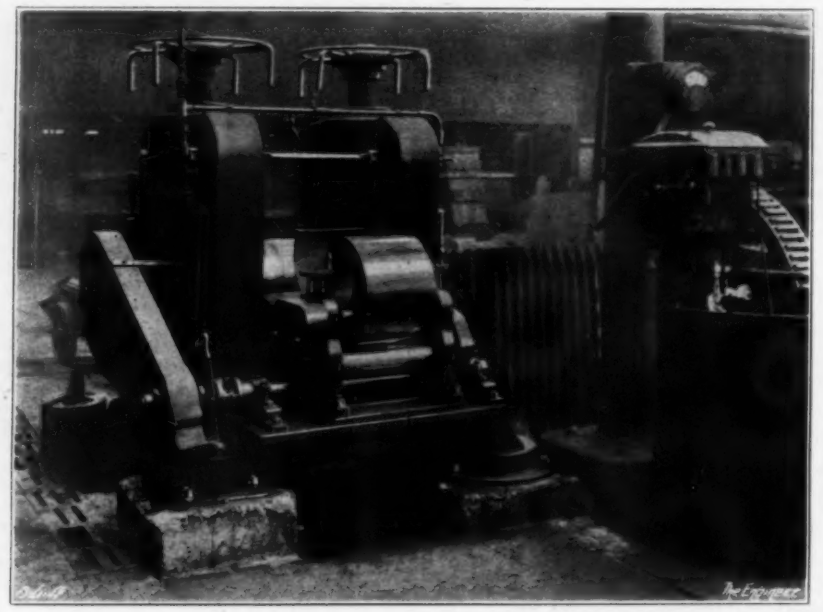


FIG. 17—ROBERTSON MILL WITH COILER MOUNTED ON HINGED BED

The work of attaching the leading end of the strip to the drum and removing the finished coil, as is necessary with the drum type coiler, has no equivalent in the operation of the roll type machines, the metal being simply entered into the rolls. It is drawn in automatically, and the finished coil is delivered above, requiring only to be lifted off.

Machines are made on this principle capable of coiling metal up to ½in. thick and as wide as 24in.

Several variations of this design are in common use, and in older types the coiler is installed as a separate machine, the coiling up of the metal being carried out after it has been removed from the rolling mill; belt and motor driving machines of the class are made, and an example of the latter is shown by Fig. 18. This is a very compact and powerful machine designed by the Torrington Manufacturing Company. The upper bending roll being adjusted at both ends simultaneously insure parallelism of the rolls.

It is not the most economical practice to treat the coiling of the metal as a separate process, and motor driven coilers, such as those described, can be mounted in line and close to the mill rolls, so that the metal is automatically led through guides to the coiler rolls, as is indicated in Fig. 16. In this way heavy metal coilers of this type may be made entirely automatic in action, and consequently eminently suitable for working with mills operating at high rolling speeds.

As a coiler fixed permanently at the back of the mill is in the way if the mill is required for rolling metal too thick for coiling, a very useful machine

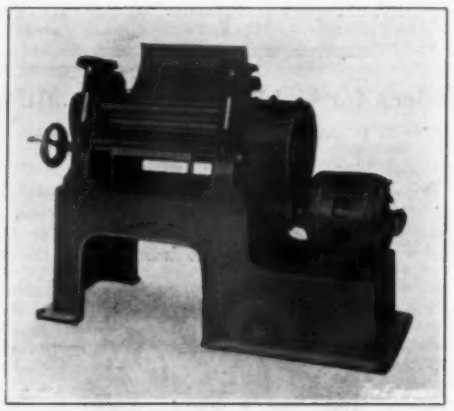


FIG. 18—TORRINGTON MOTOR-DRIVEN COILER

has been designed in which the coiler rolls are mounted on a hinged bed, so that the whole machine may be swung clear when not required, the driving gear being disconnected by a suitable clutch. This is a very popular form of the automatic roll type coiler, and many have been installed during recent years by W. H. A. Robertson and Co., Ltd. Fig. 17 shows a machine of this design arranged in conjunction with a rolling mill. The coiler rolls in this machine are driven by pitch chain from the end of one of the mill rolls or, if preferred, and more convenient, from the mill pinions, and with that design such machines can easily be fitted to existing mill, without alteration to the mill itself. This illustration shows the operation of this type of coiler very clearly, the metal being seen issuing from the coiling rolls, and being coiled on the carrier rolls above.

Sufficient friction is obtained between the bending rolls and the metal to apply a very powerful tension to the strip, and besides other advantages the use of such powerful coiling apparatus with mills effecting preliminary reductions on strip metal, prepares the way for more accurate work in the subsequent finishing mills. The same firm has recently brought out an even more powerful machine of this class, capable of coiling the heaviest gauges and widest strip, not only in non-ferrous metal, but also in steel. This machine is illustrated by Fig. 19, and has several notable features. In the first place, being designed for handling very heavy coils up to 200 lb. in weight, the coil is delivered under the bending rolls instead of above, as in the more usual design; consequently on comple-

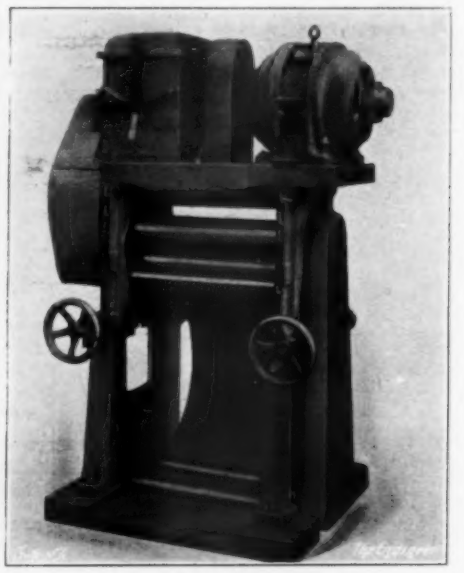


FIG. 19—COILER FOR WIDE HEAVY GAUGE STRIP

tion of a coil it is deposited practically on the floor level, and can be rolled away with the minimum expenditure of labour. The machine is exceptionally powerful and is portable, so that it can be put down behind any mill in the works, sole plates being provided by the mills to which the coiler is firmly bolted when in operation. To transfer the coiler to another mill it is only necessary to remove four securing bolts, sling the machine to a crane by eye bolts fitted, and carry it to the new position. The coiler is self-contained and motor driven, the motor being mounted on the machine frame, and is in order to accommodate the coiling speed, to the different rolling speeds of several mills, a two-speed gear-box is provided. Another form of portable coiler is shown by Fig. 20. This is a Torrington design, and carries its own driving motor, which can be run at varying speeds to suit mill rolling speeds. The machine frame is mounted

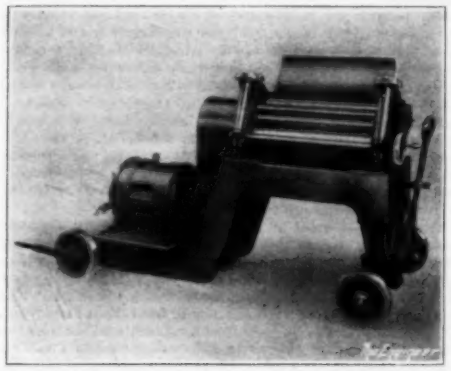


FIG 20—TORRINGTON PORTABLE COILER

on wheels for easy transfer to any mill or circular shearing machine in the plant, one pair of wheels being attached to an excentric axle, so that they may be raised, allowing the machine frame to rest on the floor when in its working position.

The drum type coiler being only suitable for dealing with metal not much thicker than sixteen gauge, and the roll type machines for metal not much thinner than that, it follows that to provide a mill with coiling equipment to handle any gauge from the thinnest to the heaviest gauges, coilers of both designs must be installed and arranged so that either may be used alternatively. This duplication of coiling gear is quite common in the United States, and an example of a high-speed strip mill of the self-contained motor driven type with double spindle coiler or blocker for the thinner strip, and roll type coiler for thick metal, is shown by Fig. 21. Such complete equipments are

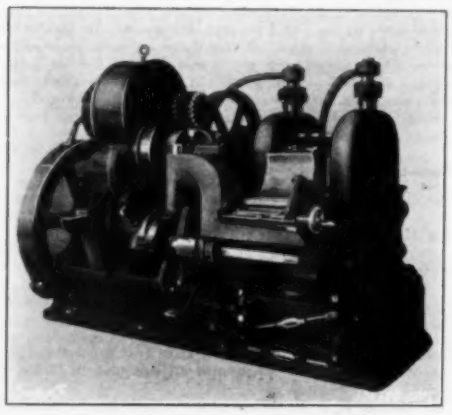


FIG. 21—COILER FOR THICK AND THIN STRIP

almost unknown in British mills, whilst the Torrington company has supplied such installations to the majority of the strip mills in the States.

As will be seen on reference to the illustration the roll coiler for heavy gauges is mounted on a hinged bracket, which can be swung clear when not in use, whilst the two spindles for drum coiling of thin metal are seen under the heavy coiler bracket and the lower jaw of the automatic "blocker" is visible behind. In this case both coilers are belt driven from the mill gearing, but in other cases, especially with larger mills, an independent motor is provided for the coiler drive. It will be understood that an elaborate equipment of high-class coiling machinery such as this is an expensive item, and, in fact, the cost of the coiler may easily represent a large proportion of the total cost of this whole mill.

It is interesting to consider, in conclusion, the relative costs of the simple winders described in the earlier part of this paper, and of such a complete equipment as that just described, putting aside hand-operated winders. The simplest form of belt driven coiler would cost, roughly, £20, whereas the complete double spindle blocker for light gauges and alternative roll type coiler for thick metal, complete with independent motor for a large mill may easily cost as much as £600. There are all gradations in cost between these limits, and the modern mill manager and engineer can select the machine which will best suit his working conditions, at a cost within his spending capacity, and while there are as yet probably very few British cold rolling mill firms which would favour such an expense as the larger figure mentioned above, for coiling equipment, it is obvious that such heavy capital expenditure is profitable to their American competitors, and it is satisfactory to find that the more progressive mills in this country already fully appreciate the advantages of powerful and efficient coiling equipment, and practically all the coilers of the more modern types described in this article are in operation in British mills. Moreover, where one up-to-date coiling equipment has been installed in a mill, in many cases the experience gained with it has resulted in repeat orders being placed for similar machines to be worked in conjunction with other mills in the same plant.

Although in the writer's opinion a great many British mills are working at a disadvantage with excessively low rolling speeds, and inadequate and uneconomical coilers, it is not intended to recommend that every mill should be equipped with the most expensive and elaborate coiling devices, regardless of cost and of the trade conditions under which the mill may be working. The selection of proper coiling apparatus requires careful study and as much attention as should be given to the mill itself. For any given duty and output condition, coilers are available, which are more suitable and economical, not only in regard to manufacturing costs, but also to capital expenditure, and, if this very incomplete summary of modern progress and practice in regard to the coiling of metal from the cold rolling mill succeeds in interesting and informing those in charge of works in the country, it will have served its purpose.

Ship Propulsion Research.

IN a paper on "The Economy of Tank Testing of Ship Forms and Research in Ship Propulsion," which was read by Mr. G. S. Baker, of the William Froude National Experiment Tank, before the North-East Coast Institution of Engineers and Shipbuilders on Friday evening last, January 28th, some of the more important aspects of the national necessity of tank experiment work were discussed. In opening his paper, Mr. Baker said:—If we claim to be the leading shipping nation of the world, and, being such, wish to retain that position, it is evident that, as other nations advance in organisation and in knowledge, we must also advance to at least the same extent. So far as the building and running of ships are concerned, this means that the only truly economical course is to pursue research and test work in this country to the same extent as is done in other maritime countries. Failure to do so will assuredly lead to a slow and painful demise.

Whatever may be said of the international character of research in general, in an imperfect world, its commercial application is national. The National Experiment Tank exists, among other things, to ensure to the reasonable owner and builder that the scientific knowledge which has been gathered by tank work shall be expressed in his ship.

We have a gift as a nation for improving on other people's ideas, which has served us well in the past, but other nations have sedulously cultivated the same quality, and science has entered the industrial field. We must be scientific or be compelled to follow our neighbour, as in the above examples, a process which is not economical. Experience and natural ability must both be guided by science if successful results are to be obtained, and this applies to shipbuilding as well as to other industries. It may be said that this is realised in the industry, but the facts are against this statement. The number of ship designs passed last year by Lloyd's in this country was something approaching four times the number of designs which were tank tested—when a reasonable allowance is made for the work of all English tanks.

Apart from the national, there is the local or personal economy to be obtained from research and test work. Briefly, one may say that to the builder:—

(*a*) Tank research places at his disposal a mass of data on which approximate designs for tendering purposes can be rapidly and with certainty completed as regards power, &c.

(*b*) If this design becomes a contract, an experiment tank will settle the exact shape of hull, propellers, &c., to give the best results. Reasonable advertisement is good economy, and no better advertisement is to be obtained by a builder than a few ships giving really good results.

(*c*) In the case of abnormal designs, power and speed contracting can be as close as with normal ones, if a tank is used. There is then no need to allow large margins for error, *i.e.*, to sacrifice displacement to ensure a low resistance or to fit unduly large engines to ensure obtaining a given speed.

(*d*) This is the complement of (*a*) above. If tank results are available, trial results become infinitely more valuable for future designs. By their analysis some insight into the relative efficiency of engine, propeller, and hull can be obtained.

From the owners' point of view, the economy of research and test in ship propulsion is represented by:—

(1) The cost of the tests can be regarded in the same light as paying insurance. For a relatively small sum, the owner is assured that amongst its class his vessel will possess a high efficiency as regards speed and cost of fuel. With the rapid development of engineering science, particularly in the type of engine now being adopted, this is of special importance.

(2) With this high efficiency his ship will stand more adverse trade conditions than other vessels, without running at a loss.

(3) There are many problems other than hull form and propeller efficiency in fine weather, which enter into the economy of ship running, such as speed keeping, rough-water resistance, steering, &c. This is not the place to deal with these in detail, but it must be pointed out that many of these items could be dealt with experimentally, and it is the worst possible economy to ignore this fact. One can be sure that others will tackle such problems and secure any advantage to be gained by such research.

(4) The contending claims as regards propulsion, &c., of different or special types of hull or propellers can be definitely settled by properly arranged tank tests.

It is left for the business man to say whether under such circumstances the expenditure of £200 to £400 involved in the complete tank testing of a ship costing anything from £20,000 to several millions of pounds, is not an economy.

The case for the economy of tank research rests far more on its national value than on any advantage to individuals. Tank research is more than an economy: it is a necessity in competing with other nations.

In the second part of his paper Mr. Baker deals with the increasing variety of tank work and illustrates some of the advantages which accrue from such work by some notes on phases of the propeller problem. The question of the shaft webs and brackets is considered, and a method of setting these correctly by means of tank experiment is referred to. Direction of rotation of propellers is further discussed and some notes are given on the shape of propeller losses and the effect of shape on efficiency. The question of propeller rake and skewback, and the advantage of rake in single-screw ships, is then dealt with, after which a concluding section of the paper deals with the general advantages, application and limiting conditions affecting the use of propellers with blades of aerofoil cross-section. In an appendix a review of the work of the William Froude National Experiment Tank is given. We note that in 1924 fifty-one models were tested for hull resistance, and twenty-six designs were tested, nineteen with propellers. The figures for 1925 were somewhat lower, but in 1926 sixty-two models were tested for hull resistance and thirty-two designs, of which twenty-three were tested with propellers. Of the thirty-two designs, three were improved 8 per cent. and over on hull change, and two 6 per cent. and over on propeller change. In three cases the hulls were tank designed, requiring no change to be made, and in several other cases hulls were improved to a smaller extent and new propellers proposed to secure desired revolutions. The work of the Tank last year also included dealing with three rudders and the plotting of the stream lines for the after bodies of four hulls, as well as attempting a steam trial and analysing five sets of trial data.

MANCHESTER ASSOCIATION OF ENGINEERS.

"THE Junior Technical School and its relation to Engineering" was the subject of a paper read before the Manchester Association of Engineers by Mr. S. Howden, M.Sc., at a meeting held on Friday, January 28th. The objects of the author were to state what a junior technical school is, and to exhibit some of the work carried out in the school with which he is connected in Openshaw. He said the boys were recruited from the elementary schools at an age when they had formed some idea of the main branch of service in which they wished to earn their living, the parent being called upon to sign an agreement that his son would attend the full course of two years and enter productive industry. They were neither "trade" schools nor vocational schools, and as much as eight hours per week were given to English subjects. The subjects dealt with were English, history, geography, mathematics, science, drawing, workshop practice and drill and gymnastics, the aim being to make sure of the fundamentals, attain manipulative skill, and form a habit of tackling mathematically any problem which was susceptible of mathematical treatment. The boys had to be able to read intelligently engineering literature, which required some mathematics. Drawing consisted for the most part of geometry and machine drawing from prints and models, representing real details of modern practice given by local engineering firms. The general elementary science which formed part of the training during the first year was divided into two groups, namely, (1) dealing with methods of measuring, length, area, volume, mass, density, pressure, &c., and teaching the use of callipers, vernier, micrometer screw gauge, hydrometer, balance and pressure gauge; (2) dealing with the properties of materials and the differences in the behaviour of materials when force was used. When this preliminary work had been accomplished, the time devoted to the subject in the second year was divided as follows:—Physics, one and a-half hours; chemistry, two and a-half hours; and mechanics, three hours. Six hours per week were devoted to workshop practice and patternmaking. The question of "costing" was introduced in order to make the lads see the mutual dependence of the various departments of a factory and the meaning of overhead charges, both inside and outside the works. Other important features of the training were visits to local foundries, the making of mechanical models from the students' own drawings, and calculations and work on the common kinds of machine tools. On leaving the school the boys could continue their technical education in the part-time day department of the Manchester College of Technology. The author maintained that these junior schools had fully justified their existence, and said that by making use of them engineering firms could get some return for the rates paid for their maintenance.

AT a conference at Plympton on Friday, January 21st, of representatives of the authorities concerned, a scheme was approved for the provision of a water supply to Brixton and Newton Ferrers, which involves the laying of 6 miles of mains and the construction of a service reservoir at Newton Ferrers.

The Use and Economy of High-pressure Steam Plants.*

By Professor A. L. MELLANBY, D.Sc., Member, and Professor WILLIAM KERR, Ph.D., Member.

(*Continued from page* 109.)

THE MAIN INFLUENCES OF HIGH STEAM CONDITIONS.

Materials.—On all attempts to reach extreme pressures and temperatures the problem of materials exercises a controlling influence. It represents the main factor limiting the boundaries of ultimate achievement, and the main difficulty restricting advance thereto. Higher pressures and superheats, through stress action and the weakening influence of temperature, increase the severity of the conditions inflicted on the materials in a sort of double progression. The boilers and turbines are concerned, in differing degree, and it is essential to appreciate how the strength and usefulness of metals are affected, if any genuine estimate of the difficulties of advance is to be formed.

The quality of the resistance offered by a material to corrosive and erosive influences will always arise in steam plant applications. Whatever degree of excellence this resistance may attain under moderate conditions of working must be maintained at the higher values. This aspect of the subject of materials raises wide issues not capable of reasonable treatment here; but it is fairly clear that the steady development of modern materials can meet the requirements satisfactorily. Both Sir Charles Parsons and Sir Robert Hadfield have referred to the excellence of the newer materials—presumably nickel-chrome steels and alloys—in this respect, and are apparently satisfied with the promise. In any case, corrosion is not purely an effect of higher steam pressures. It is present and troublesome to some extent in normal conditions, and the natural tendency to greater care in the elimination of impurities and occluded gases in the feed water will probably reduce the difficulties to reasonable limits, even at higher temperatures. And, in any case, the matter takes a secondary place in comparison with the waning strength of metals as the temperature increases.

But one side of this matter might be referred to in passing, as it is not fully appreciated. It has been shown[3] that a hot boiler tube, above a certain temperature, produces some slight dissociation of the steam, with evolution of free hydrogen—and presumably oxidation of the metal. The effect is just of reasonable magnitude at or above a metal temperature of 900 deg. Fah. with ordinary boiler tubes, and increases rapidly thereafter. If this should prove fundamental and general with all metals a limitation of some moment is introduced; but it is perhaps probable that special materials will delay the critical condition.

The reduced strength of metals at high temperatures is, however, the primary and most definite effect to be considered, and in this connection the notable work of recent years on the phenomena of "creep" takes on a special significance. It provides as it were a new and more stringent basis for judgment of the applicability of metals in the higher temperature ranges, and certainly displaces the strength figures, commonly determined by direct test, as the criteria of value.

A metal subject to stress over a period of time at a temperature above some moderate and characteristic limit will fail, by creep, at a much lower stress than that indicated by a straightforward break after heating. This feature has been adequately demonstrated, and Professor Lea's paper[4] before this Institution two years ago provides a very clear exhibition of the effects. For any temperature the stress causing ultimate fracture depends on the time, but a limit is finally reached below which failure will not occur. This is the "creep limit" for the metal at the temperature of investigation; and when determined for a series of values the "creep limit curve" is obtained. This curve must take the place of the usual strength-temperature diagram.

Thus, taking the direct strength under a "quick break" at any temperature as the basis figure for that temperature, Fig. 1 shows the percentage reduction of this apparent strength by creep effects, for a few different materials. Fig. 2 shows, in another way, the relation between the direct-strength and creep-limit curves for the carbon steel and the nickel-chromium alloy of Fig. 1, the former representing the effect for an ordinary material and the latter displaying the highest creep limits that have so far been reached. It will be appreciated from these diagrams that the effect is quite extraordinary. In view of it, non-ferrous materials of the brass or bronze type practically cease to have any real value in the high temperature field.

The consequences of the fact of creep failure simply amount to the degeneration of what is commonly understood as a factor of safety, on a stress basis, into a mere margin of safety, on a temperature basis. Thus, the carbon steel of Fig. 1, if subject to a stress of, say, 7 tons per square inch at 900 deg. Fah., would have an apparently ample factor of safety as based on direct strength, but would have no real margin of safety on temperature considerations. While, in general, the first method of judgment might be as good as the other when it was certain that the temperature value would not be exceeded, it ceases to have any merits when—as in boilers—the metal temperatures are not necessarily confined within narrow limits.

The general order of creep effects, and the type of relationship between creep limit and direct strength curves are fairly similar for different metals, and it has been shown[5] that the time, e hours, that will elapse before fracture occurs under a stress S tons per square inch at temperature θ, is expressible in the form

$$e = \frac{a_1(\theta_\circ - \theta) + a_2}{1 - (\theta_\circ - \theta)(\beta_1 + \beta_2 \cdot S/\theta)} \quad . \quad . \quad . \quad (1)$$

where a and β denote coefficients that can be determined by experiment, and $\theta_\circ$ is the temperature at which the stress S would produce practically immediate failure.

If equation (1) gives a negative result, the conclusion is that failure will not take place under the conditions employed. The point falls on the safe side of the creep-limit curve, and the degree of security is then measured by the temperature margin $\Delta\theta$, which may be read from a "creep-strength" curve, such as in Fig. 2, or, in the notation of equation (1), is expressed by

$$\Delta\theta = (\theta_\circ - \theta) - \frac{1}{\beta_1 + \beta_2 \cdot S/\theta} \quad . \quad . \quad . \quad (2)$$

If the temperature is liable to a fluctuation exceeding this, the security vanishes.

The points dealt with represent the salient aspects of the materials problem in brief summary. They are hardly the whole matter, however. Even when the temperature margin may appear reasonable, the metal is not necessarily clear of the possibility of trouble. There may be very limited elastic properties, and a certain initial flow may occur. Creep failure might then become possible in a cumulative manner by stress increase due to distortions that are not accommodated. Hence, design with moderate temperature margins requires extreme care, and a really profound knowledge of the properties of the material employed.

In so far, then, as the problem of materials can be reduced to a simple and single point of view, it may be considered expressed by the conception of the temperature margin.

Boilers.—Many notable changes have occurred in boiler practice. The idea of high unit powers seems to have created the ambition of a single boiler turbine condenser system, and, although this is not actually achieved, the advance in the mere dimensional aspect of boilers has been most striking. But such an advance was really always open. It is not a necessity of high pressure. It is only an outcome of the more intensive development in all directions that has accompanied, or has been prompted by, the movement towards higher economy.

Very much the same remark could be made regarding most of the obvious features of this line of development. Improvements in stoker practice, employment of pulverised fuel, changes in furnace dimensions and operation, the careful control and study of combustion, the development of radiant heat elements in the form of the much-discussed "water walls" or of radiant type superheaters, the partial disappearance or complete elimination of the economiser; and the development of air pre-heating on a new scale—these were all possible to the ordinary steam plant, and in a technical sense are only remarkable because of their concurrent development.

The most direct effects of the call for higher pressure on boiler design are exemplified by three new methods of steam generation that have reached the stage of full-scale trial within recent years. These are the Benson "critical pressure" boiler, the Atmos "revolving tube" type, and the Löffler system. Each endeavours to overcome in a different way the troubles incidental to steam formation by violent ebullition. All have been fully described in the technical Press[6], but information on which to base judgment of values is rather meagre.

These new methods are ingenious, and are, in a sense, more notable developments of the period than are exhibited by the elaborations and perfection of standard practices. But they have hardly yet affected boiler methods, and with probably the single exception of a large plant for Czecho-Slovakia on the Löffler system, all the major installations are of well-established types. To a critical view, although unsupported by full evidence, the Benson and Atmos methods would appear rather extreme attempts to overcome moderate difficulties, and the Löffler process, wherein the combustion gases are wholly concerned with superheating, promises to express all boiler difficulties in terms of superheater difficulties, and to create extreme conditions not less onerous than those of radiant type superheaters.

Our immediate concern is the hindrances to pressure advance; and none of these new methods can really promise immunity from the essential difficulties. These difficulties are clearly displayed by the paramount requirements of pure feed water and the reliability of materials.

The feed-water problem is of increasing seriousness as the operating pressures and temperatures rise. The solubility of those substances that produce scaling decreases with rise of temperature, and they must be reduced or eliminated by suitable treatment. Even although evaporator make-up alone is used, a slight condenser leakage is sufficient to cause trouble. The employment of a double condenser arrangement in marine work, as in the King George V., would appear a necessary safeguard in such application in order to permit of immediate attention if salinity of the water should be detected, and to permit this without stoppage of the plant.

The pre-treatment of feed water to remove the hard scale-forming bases, by methods that do not produce harmful gases in the steam, is a chemical problem of some magnitude. On the other hand, the proper de-aeration of the condensate to remove oxygen and other gases that may aid corrosion is an engineering operation largely met by the adoption of closed feed systems and de-aerators. The conjoint employment of all such methods appear to lead to satisfactory results. And it is highly probable that any required degree of perfection to safeguard the boiler elements and the turbine expansion passages can be attained for any pressure and temperature within the limits at which the materials difficulty takes precedence of all others.

This materials problem may be set as a consideration of the metal wall temperatures as the operating conditions become more severe. The high-presure boiler, as it appears to be developing, may be taken as composed of a radiant heat absorbing section—water walls and lower tube rows—a first boiler section, an intermediate or "interdeck" superheater element, a second boiler section, and an air pre-heater. The economiser promises to disappear as its direct function is so well performed by stage feed heating, and its beneficial influence in "flattening" out the boiler efficiency curve is adequately performed by the pre-heater. Any inclusion of steam re-heating elements within the main boiler setting only raises the same problems as of the primary superheating section.

The tubular furnace walls receive heat by direct radiation. There is little real knowledge of the magnitude of this effect, but it appears to be reasonable to assume that the total heat received is a proportion of the total furnace heat depending on the ratio of the heat developed to the absorbing surface presented. Several American writers[7] have recently dealt with data of the kind from the large boilers now in use, and present the results in this order. A more elaborate study of the matter might be possible, but would be fruitless at this juncture, and for the simple purpose in view, since it would depend on those data that seem already well met by the method mentioned.

It follows that the heat absorbed per square foot of radiant surface is expressible by—

$$Q = \mu \cdot C \cdot F/X \quad . \quad . \quad . \quad (3)$$

where Q = heat per square foot radiant surface per second.
C = coal per second.
X = surface in square feet.
F = heat per lb. coal.

For μ Orrok[8] has given the expression—

$$\mu = \frac{1}{1 + L\,\frac{\sqrt{C/X}}{27}} \quad . \quad . \quad . \quad . \quad . \quad (4)$$

where L is air per pound coal, and in this form the radiation equation merely represents an adaptation of an old formula of the kind.

No matter how the tubes receive their heat externally, the transmission of this heat to the fluid within is by convection, and a rough estimate of the order of the wall temperature may be made by convection methods.

In the fully convective transmission of heat from a gas at temperature T, through a metal wall at θ, to an internal fluid at t, the heat per square foot per second is

$$h_1(T_1 - \theta_1) = h_1'(\theta_1 - t_1) = \bar{h}_1(T_1 - t_1) \quad . \quad (5)$$

in which h_1 is the transmission coefficient, gas to metal; h_1' the coefficient for metal to fluid; and $\bar{h}_1$ the usual "overall" experimental coefficient that ignores the wall temperature. The suffix $_1$ merely denotes that this is the first case of the kind here. These h_1's are really approximate representations of the Reynolds's coefficients, and therefore the ratio of h_1' to h_1 may be taken as—

$$\frac{h_1'}{h_1} = \frac{s_1' \rho_1' v_1'}{s_1 \rho_1 v_1} = r_1 \quad . \quad . \quad . \quad . \quad . \quad (6)$$

where s, ρ and v are respectively specific heat, density and speed of the fluid. Strictly, such a ratio should have a correction factor, acting through viscosities and conductivities, to allow for the effects of the viscous films;

Fig. 1.—*Reduction of Strength by Creep.*

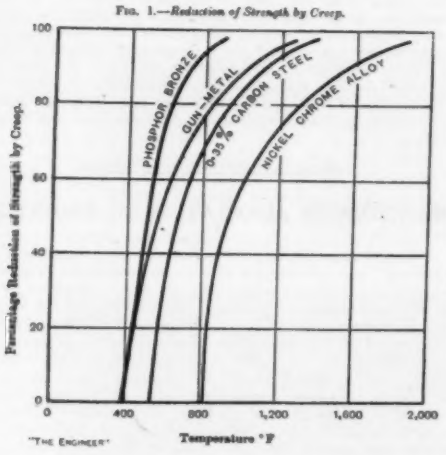
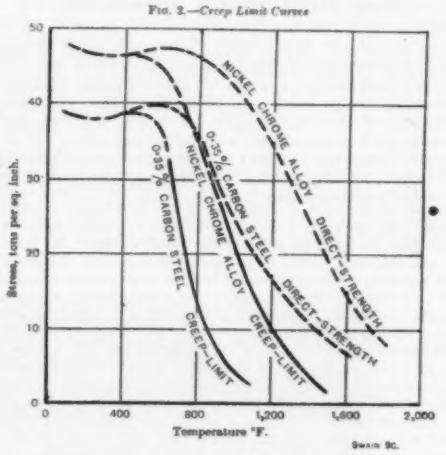


Fig. 2.—*Creep Limit Curves*



* The Institution of Mechanical Engineers.

[3] "On the Production of Hydrogen by Steam in a Hot Boiler Tube," Porter, *Journal* of the Royal Technical College, December, 1925, page 14.

[4] "Effect of Low and High Temperatures on Materials," "Proceedings," I. Mech. E., December, 1924.

[5] "Failure of Metals by Creep," Kerr, "Proc.," Inst. Engineers and Shipbuilders. in Scotland January, 1926.

[6] "The Benson Boiler," *Power*, May 22nd and 29th, 1923; THE ENGINEER, February 22nd, 1924; "The Atmos High-pressure Boiler," THE ENGINEER, February 27th, 1925; "The Löffler System of High-pressure Steam Generation," *Engineering*, April 17th, 1925.

[7] "Radiation in Boiler Furnaces," Broido, *Mech. Engineering*, February, 1926.

[8] "Radiation in Boiler Furnaces," Orrok, *Mech. Engineering*, March, 1926.

but in view of the controversial and relatively small nature of such corrections, together with the essentially simple and general guidance sought, elaborations of this kind may be excluded.

From (5) and (6) it follows that

$$h_1' = \bar{h}_1 (r_1 + 1),$$

and, since in this case $\bar{h}_1 (T_1 - t_1) = Q$, there follows—

$$\theta_1 = \frac{Q}{\bar{h}_1 (r_1 + 1)} + t_1 \quad . \quad . \quad . \quad . \quad (7)$$

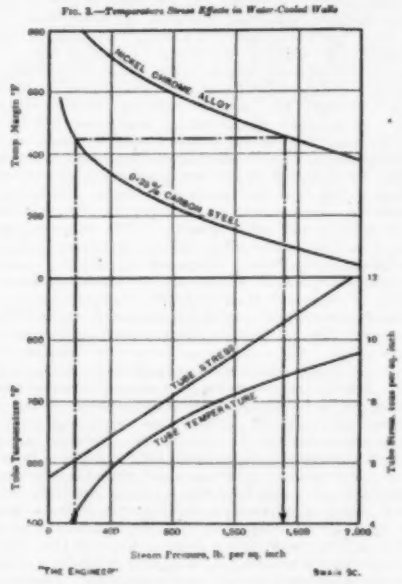
The quantity $\bar{h}_1 (r_1 + 1)$ is roughly constant, and for gas-metal-water conditions may be of the order 0·43. But with water walls the outlet fluid may be practically saturated steam and with a specific heat ratio, water to steam of, say, two to one, the quantity $\bar{h}_1 (r_1 + 1)$ may be taken as 0·22.

According to the radiation data available, a figure of 30 for Q would represent a fairly high value, commensurate with a rather small radiant heat surface. But since, even with large surfaces, the heat absorbed may vary at different parts, and in any case when the side walls are not water-cooled, the lower tube bank presents only a moderate surface to the furnace, the value may be taken as reasonable. It is impossible to meet all the probable conditions without losing the desired simplicity, and it may be assumed that for any arrangement there is always some forcing rate at which this transmission is possible.

Hence it would appear that the radiant heat metal surface may be, roughly, about 140 deg. Fah. above the temperature of the steam. Many steps in elaboration of the analysis are obvious which would lead to a more complex order of change with steam pressure, but all of them are rendered inconclusive by inadequate data at some essential point.

The simple result obtained leads to the metal temperatures shown in Fig. 3. Even up to the highest pressures the temperature does not appear excessive. It should be appreciated, however, that internal scaling of these tubes is a critical matter. Owing to the dependence of the radiation on the fourth powers of the temperatures even a considerable rise of the metal temperature would hardly

FIG. 3.—*Temperature Stress Effects in Water-Cooled Walls*



affect the heat absorbed, and a very moderate scale formation might easily lead to prohibitive temperatures.

But even without such an effect the metal wall temperature in this case provides no real basis of judgment. It is the temperature margin on the creep limit that should be employed, and for this the stresses are required.

For a tube subject to an internal pressure, P lb. per square inch, and transmitting heat Q B.Th.U. per square foot per second from the outside inwards, the maximum stress in pounds per square inch is given by

$$f_1 = P \left\{ \frac{1 + x^2}{1 - x^2} \right\} + \frac{E \,.\, c \,.\, Q \,.\, b}{2\,k(1 - \sigma)} \left\{ \frac{2 \log_e \frac{1}{x}}{1 - x^2} - 1 \right\} \quad (8)$$

in which b = external radius, inches.
x = internal radius/external radius.
E = modulus of elasticity in pounds per square inch.
c = coefficient of expansion per deg. Fah.
k = coefficient of conductivity in B.Th.U. per second per square foot per inch.
σ = Poisson's ratio.

Taking a tube 4in. external diameter and ½in. thick—as used in the Hell Gate station boilers[9] in America—the stresses are as shown in Fig. 3. It should be noted that the assumption of the same tube thickness for all pressures is quite legitimate, since any attempt at thickening to meet the pressure stress in the first terms of (8) would increase the temperature stresses given by the second term.

By means of the wall temperatures and stresses so obtained and the creep limit data of Fig. 2, it is easily possible to determine the temperature margins shown by the upper curves of Fig. 3.

It will be observed that at the highest pressures the security, in the case of ordinary steel, has practically vanished, and that to obtain thereat the same margin of safety as this material provides at the lowest pressure would necessitate the employment of special metals. It should also be remarked that the use of "fins" on these tubes may easily produce high local temperatures and stresses, that would render the margins displayed in Fig. 3 rather generous in their allowance.

The lowest tube rows of the boiler are in much the same condition as the side walls. But the superheater tubes above the first boiler section deserve a little consideration, and the corresponding treatment for this case may be briefly outlined.

The heat transmission here is purely by convective processes and the corresponding equation to (5) may be written

$$h_2 (T_2 - \theta_2) = h_2' (\theta_2 - t_2) = \bar{h}_2 (T_2 - t_2) \quad . \quad (9)$$

and with

$$\frac{h_2'}{\bar{h}_2} = r_2$$

there follows

$$\theta_2 = \left(\frac{T_2 - t_2}{r_2 + 1} \right) + t_2 \quad . \quad . \quad . \quad . \quad (10)$$

To serve the present purposes a value of 25 may be taken for r_2. This corresponds to a rate of combustion gas flow of about 3 lb. per second per square foot of flow area and a steam speed within the tubes of about 50ft. per second

FIG. 4.—*Temperature Stress Effects in Superheater Tubes.*

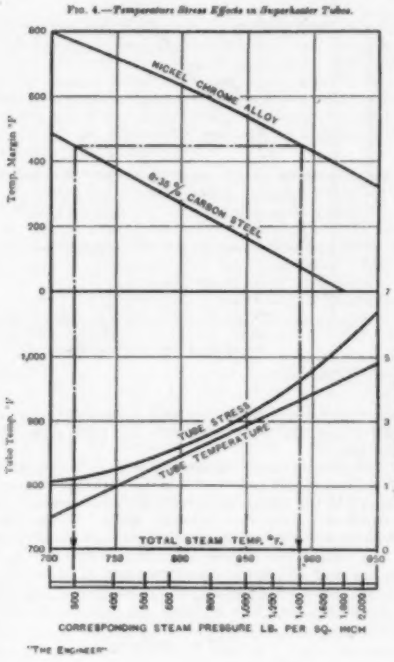
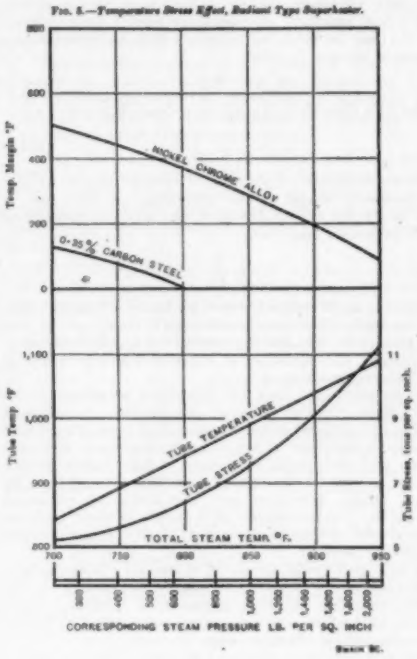


FIG. 5.—*Temperature Stress Effect, Radiant Type Superheater.*



at the lower pressures. While the latter may be high for low pressures, the employment of a constant r_2 value probably renders the corresponding value low at the high pressures, and this may somewhat exaggerate the rise of θ_2 with steam temperature. It may also be assumed that by the time the combustion gases reach the superheater tubes they have been cooled to, say, 2000 deg. Fah. The value of t_2 can be taken as the total steam temperature in any case, as with a counter-flow arrangement the inlet gases first meet the outgoing steam.

With these various conditions applied to equation (10), the metal wall temperatures of Fig. 4 are obtained, as based on total steam temperature. These are naturally higher than the radiant water-cooled surface temperatures of Fig. 3, but the stresses are not now so severe. For these the similar equation to (8) is

$$f_2 = P \left\{ \frac{1 + x^2}{1 - x^2} \right\} + \frac{E c \bar{h}_2 (T_2 - t_2) b}{2\,k(1 - \sigma)} \left\{ \frac{2 \log_e \frac{1}{x}}{1 - x^2} - 1 \right\} \quad (11)$$

in which the only change is the substitution of $\bar{h}_2 (T_2 - t_2)$ for Q.

With tubes 2in. external diameter and 0·15in. thick the stresses shown in Fig. 4 are obtained. In this procedure pressure and total temperature have been allowed to progress together in such a manner that the superheat is practically the same at all pressures. Owing to the relative smallness of the temperature stresses in this case it would be possible to counter the effect of pressure to some extent by tube thickening, but the stresses are not very severe and the correction need not be made here.

With the metal temperatures and stresses established, the temperature-margin curves are obtained as before, and it will be seen that the conjunction of higher temperature and lower stress in the superheater tubes leads to much the same degree of security—or insecurity—as the combination of higher stresses with lower temperatures in the radiant heat surfaces of Fig. 3.

For radiant type superheaters the procedure would be a combination of the two cases already studied. If it be assumed that the radiation per square foot is the same in such an arrangement as has been taken for the side walls, severe issues are raised. The calculation for wall temperature θ_2 would be by

$$\theta_2 = \frac{Q}{\bar{h}_2 (r_2 + 1)} + t_2 \quad . \quad . \quad . \quad . \quad . \quad (12)$$

and for stress by equation (8); for Q = 30 and tubes of 3in. external diameter and 0·20in. thick this would lead to Fig. 5.

It is obvious that the employment of this type of element would be seriously restricted by pressure and temperature advances, and it may be presumed that this limitation will affect its use with ordinary boilers at high total steam temperatures, and will exercise the main restraining influence on the maximum temperatures open to the Löffler system.

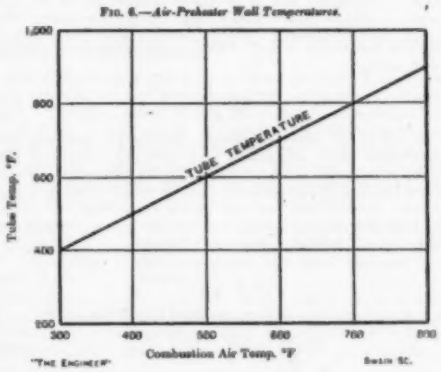
Air pre-heater tubes are not subject to any severe stress action, and the wall temperatures will not be high except in the event of considerable advance in combustion air temperatures. It is sufficient to notice that the tube temperature in such cases is practically the mean of the air and gas temperatures, owing to the similarity of the fluids and their conditions of flow on the two sides of the tube wall. Hence, with, say, a 200 deg. Fah. difference between the chimney and inlet air temperatures, and a counter-flow arrangement for the gases, the maximum tube temperature would be roughly 100 deg. Fah. above the final combustion air temperature. This leads simply to Fig. 6, which shows the growth of the wall temperature consequent on any attempts to exploit higher air temperatures, on the assumption, of course, that the boiler surfaces are arranged to suit.

The conceptions that have been formulated, and the facts that have been portrayed, in this study of metal temperatures are admittedly approximate. The methods have been kept within quite moderate bounds, however, and the results are by no means the worst that are possible in a boiler not in the best condition and subjected to forcing. The net consequence of the points that have been made must be recognised as the simplified issue of the materials question arising in any progress towards high pressures and temperatures, and any steps in such progress that do not fully contemplate such influences must be deprecated.

Turbines.—Under moderate steam conditions there has always been, with large turbine units, the outlet end problem of the leaving loss. The employment of high pressures introduces an inlet end difficulty also. The exhaust end demands the adequate accommodation of huge steam volumes; at the inlet end there arises the question of the efficient guidance of very dense steam in small passages. The outlet problem has led to the subdivision of the end stages in double flow or "multi-exhaust" systems, and the high-pressure end difficulty leads likewise to the separation of the turbine sections, so that the high-pressure conditions may be dealt with apart, in a small compact cylinder suited in size and design to the extreme densities and temperatures at inlet.

The material of such a unit will have to be capable of

FIG. 6.—*Air-Preheater Wall Temperatures.*



withstanding fair stress at considerable temperature, but generally the proposed temperature of operation is a sufficiently clear indication of the severity of the conditions, since it should be possible to design for the same stresses at all pressures. With high temperatures, the likelihood of casing distortion may require special consideration, and the necessity for symmetrical design and the avoidance of extraneous steam pipe thrusts is obvious. Owing to the small clearances allowable, distortion must not occur, and with anything approaching small temperature margins on the creep limit, there is absolutely no security. But as only a relatively small portion of the turbine material is subjected to the highest temperature of the steam, it is possible to employ special metals for these parts.

In such circumstances the main influence of high steam conditions on the turbine is measured by the effect on the stage efficiencies, and the modification of these characteristic values by pressure advances requires consideration.

The authors have elsewhere[10] developed their main

[9] "Water-lined Furnace Walls for Power Station Boilers," *Engineering*, January 16th, 1925; "Water-cooled Furnace Walls," by H. D. Savage, *Year Book*, Amer. I. and S. Inst., 1925, page 114.

[10] "The Limiting Possibilities in Steam Plants," "Proc.," N.E. Coast Inst. Engrs. and Shipdrs., February, 1925.

arguments in this connection, but a brief recapitulation may be permitted for the sake of clearness.

The necessary employment of a separate casing for the high-pressure end permits the adoption of the best speed—by gearing or by separate drive—and a definite guidance to the proper speed relationship between the special and ordinary turbine sections is afforded by the condition of constant disc friction loss.

To effect this, the value of

$$\left(\frac{u}{V}\right)^{(3)}(D^2)$$

where V = specific volume,
u = blade speed,
D = diameter,
should be kept constant. The blade speed may be maintained constant by allocation of the same heat per stage at all pressures, and since, then, the diameter varies inversely as the revolutions, the disc loss appears of the order

$$z_1 \propto \frac{1}{R^2 . V}$$

where R represents speed of rotation. If z_1 is constant R must vary inversely as the square root of the steam volume. The product of initial pressure and volume (P_1 and V_1) may be taken as constant and the speed of the high-pressure section is then

$$R \propto \sqrt{P_1}.$$

Hence the disc loss for any state at volume V is given by—

$$z_1 \propto \frac{1}{P_1 V} \quad . \quad . \quad . \quad . \quad . \quad (13)$$

The same argument does not, of course, apply to the normal pressure range of the machine. Below, say, a pressure of 200 lb. per square inch, the speed is unaffected by initial pressure, and then

$$z_1' \propto \frac{1}{V} \quad . \quad . \quad . \quad . \quad . \quad . \quad (14)$$

The scheme so developed would result in an approximation to constant efficiency conditions if this type of loss were alone active. But having settled the speeds and therefore diameters, the variation of other loss factors must be accepted as a consequence.

It may be advanced that this process of establishing the order of effects by the primary assumption of constant disc loss is not general enough, since it is hardly of direct significance in the case of the reaction turbine. But this type must also seek small diameters at high speeds in the endeavour to obtain the maximum blade heights with increasing steam densities, and the order of variation established by consideration of a characteristic impulse type loss serves the purpose as well as any other method that might be devised.

The nozzle and blade losses, or steam-way losses generally, must contain a large factor simply dependent on the steam-flow energy, which is therefore a constant effect with equal heat allocation per stage under different initial pressure conditions. Hence, say

$$z_2 = C \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (15)$$

But a portion of the steam passage influences must reflect the size factor also, and hence will have a variable effect. This is rather difficult to assess, owing to the lack of knowledge of the component factors in flow losses, but it might be simply imagined proportional to passage length and inversely as the square root of flow area A. The area may be taken directly as the specific volume V; while the length, which will hardly reduce so rapidly as the diameter, may be allowed a variation as the square root of the diameter. Hence

$$z_2 \propto \sqrt{\frac{D}{V}}$$

and with $D \propto \frac{1}{R}$ and $R \propto \sqrt{P_1}$

there follows

$$z_2 \propto \frac{1}{P_1^{\frac{1}{2}} . V^{\frac{1}{2}}} \quad . \quad . \quad . \quad . \quad . \quad (16)$$

and, for the range below 200 lb., not concerned with the speed changes

$$z_2' \propto \frac{1}{\sqrt{V}} \quad . \quad . \quad . \quad . \quad . \quad . \quad (17)$$

To allow for leakage effects the simple assumption is permissible that minimum and constant working clearances, to a large extent unaffected by diameter—at least where leakage is important—can be established and maintained. Hence, the leakage losses vary with the ratio of the diameter to the steam volume or, by the introduction of the speed relation, there is obtained

$$z_4 \propto \frac{1}{V \sqrt{P_1}} \quad . \quad . \quad . \quad . \quad . \quad . \quad (18)$$

and, as before, for the non-variable speed range

$$z_4' \propto \frac{1}{V} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (19)$$

On the basis of a gear drive for the special high-pressure unit all stages within this unit should be charged with the gearing efficiency e; and, again, all stages working in the wet field should be corrected by a factor which is sufficiently represented by the dryness fraction q.

To change the proportional statements for losses into specific values it is necessary to establish standard losses. Suppose that the condition of dry steam at 100 lb. is taken as standard and that the respective loss fractions thereat are represented by, Z_1 &c. Since the stage efficiency is

$$\eta = q . e (1 - \Sigma z)$$

above 200 lb. pressure, and—

$$\eta' = q (1 - \Sigma z')$$

below that limit, then by introduction of the known loss factors and with due recognition that the standard stage lies in the fixed speed range, there follows—

$$\eta = \left\{(1-C) - \left(\frac{900 Z_1}{P_1 V} + \frac{8 Z_2}{P_1^{\frac{1}{2}} . V^{\frac{1}{2}}} + \frac{63 Z_4}{P_1^{\frac{1}{2}} . V}\right)\right\} q . e \quad (20)$$

and—

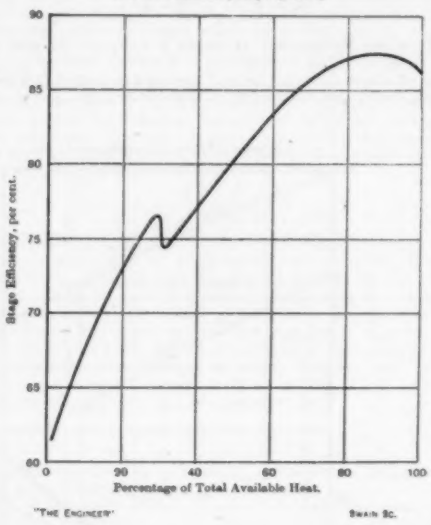
$$\eta' = \left\{(1 - C) - \left(\frac{4 \cdot 5 Z_1}{V} + \frac{2 \cdot 1 Z_2}{V^{\frac{1}{2}}} + \frac{4 \cdot 5 Z_4}{V}\right)\right\} q \quad (21)$$

When allowances such as the following are made, viz.—

$$C = 0 \cdot 10, Z_1 = 0 \cdot 03, Z_2 = 0 \cdot 07, Z_4 = 0 \cdot 03,$$

as suitable for the 100 lb. standard stage, the value of η can be calculated for any assumed conditions. To show the nature of the variation of the stage efficiency for a high-pressure plant, equations (20) and (21) have been used for the case of an initial pressure and temperature of 1500 lb. and 900 deg. Fah. respectively, with re-heating to the initial temperature of 250 lb., and exhaust at 0·5 lb.

FIG. 7.—*Variation of Stage Efficiency.*



The results are shown by Fig. 7, which gives an indication of how the stage efficiency will vary along the expansion line.

The normal range efficiencies of Fig. 7 are not impossible of achievement, but it would be difficult to say whether the fall in the higher pressure regions is excessive or underestimated. But the general order of variation seems rational and the equations derived may be allowed to give a fair indication of how efficiency is affected by pressure. In thermal efficiency considerations of different pressure cycles, such an effect must be included; otherwise the conclusions are too strongly in favour of the highest pressures.

(To be continued.)

South African Engineering Notes.

Industrial Expansion.

THE progress made in the industrial expansion of the Union was recently illustrated in the case of an order for 10,000 steel pails, given by the Johannesburg Town Council to a manufacturer in the town. The contract was secured in the face of heavy competition from all quarters. It is interesting to note that all the bolts and nuts required by the Council are manufactured in the town, while the municipal requirements in the way of tar are filled either from Witbank (Transvaal) or Waschbank (Natal). It is stated that the hundreds of brushes used to sweep the streets are manufactured in Johannesburg, while almost all the paint required is made there. In the matter of paint manufacture, the Union is now able to compete with the biggest manufacturers overseas. All the cement used is manufactured in the Union. Even aluminium number plates, which had always been imported up to quite recently, are now being obtained locally. Among recent industrial ventures in the Union was the opening of a new mill at Melmoth, in the heart of Zululand, which is the biggest wattle-extracting mill in the world, and is equipped with the very latest in efficient plant. It is owned by the Natal Tanning Extract Company. A new company has been registered in the Transvaal to trade under the name of the Transvaal Corundum Company (1926), Ltd. The capital of the company is £75,000, and it is acquiring certain property, plant and mineral rights, and intends to mine corundum, the export of which is increasing considerably. The house of Schweppes, the well-known firm of mineral water manufacturers, has established in Johannesburg the largest and most up-to-date mineral water factory in South Africa. It is situated in New Doornfontein, a part of Johannesburg that is rapidly developing as an industrial suburb. The firm intends to produce mineral waters under the most hygienic conditions. The machinery is of the latest type, while the water used is pumped from a bore-hole to a filtration plant, after which it is gravitated and again filtered. Interesting developments are expected shortly regarding the extension of chemical product manufacturing in South Africa, as it is understood that a European firm is negotiating for the erection of a plant for the production of well-known products. In Cape Town at present Wade and Dorman, Ltd., structural engineers, and A. and J. Main and Co., Ltd., structural engineers, are erecting large works not far apart, where they will carry large stocks of bridge ironwork, steel trusses, steel plating, joists, angles, &c., while compressors for automatic riveting are being installed, as are also heavy shears for cropping, electric power saws, radial drills, &c. Messrs. Main's premises cover 80,000 square feet of space, and when busy some 200 men will be employed. The works are supplying at present big single spans of 85ft. for the tramway company's garage, each weighing 2½ tons; also the steelwork for the Government's new ordnance stores, which require about 400 tons. In the near vicinity Baldwins (S.A.), Ltd., are erecting works where they will carry stocks of steel, plain and galvanised sheets, mild steel plates, black sheets, boiler tubes, &c., and will install the necessary machinery. Within a radius of half a mile to a mile of these works, Price's (S.A.), Ltd., have just erected a candle factory, close to the railway. Just behind them is a large site upon which the African Tobacco Company, Ltd., is putting up a factory; on the next industrial site the Lion Match factory has now got into swing in its new premises. On the other side of the railway, the United Tobacco Company (South), Ltd., is proceeding with the foundations of a tobacco factory to cost £64,000, all the structural ironwork being supplied by Dorman, Long and Co., Ltd.—Wade and Dorman is the South African branch of the firm. In the same locality the South African Woollen Company has quite recently opened its new woollen factory, which is four times the size of the old one, and employs about 500 hands. In addition, there is a number of smaller factories being built in this industrial area. Similar activity is reported from other centres, especially Johannesburg and Port Elizabeth. In the latter place the General Motors (S.A.) is spending £14,000 in the extension of its motor car assembling factory, where, in addition, many parts are made and bodies built. A new boot factory is being put up for the Port Elizabeth Boot Factory, Ltd., and the British United Shoe Machinery Company is making big additions to its factory, and £35,000 is being spent by the Boere, Saamwerke Beperk on a new wool store with pressing machinery. Taking the whole Union, some seventy factories, costing from £1500 and upwards to £70,000, are now in course of construction, and it is probably a record in industrial activity in the country.

Pretoria Railway Workshops.

The brass and iron foundry at the Pretoria workshops is probably, taken all round, the most modern in any of the Union Railway workshops, though the establishment of at least one private firm can claim to be of more modern design. A description of the Pretoria equipment was recently given in an article in the *S.A. Railways and Harbour Magazine*. It consists, together with the usual foundry equipment, of two 4-ton cupolas, moulding machines, and blast apparatus, reverberatory furnace, overhead electric traverser, cranes, sand sifters, grinders, pig iron breaker, rumbling machine, air hoist, core ovens, sand bins, hydraulic moulding mill, face plates, scales, and hand core-making machines. Castings may be of either of the following metals:—Grey iron, copper alloys—*i.e.*, brass, such as used for certain locomotive mountings, carriage fittings, &c., and bronze for locomotive axle-boxes. A number of moulding machines are in use. Z.A.S.M. type axle-boxes, brake blocks, fire-box moulds, &c., are all made by such machines. A hydraulic moulding machine for Z.A.S.M. type carriage and wagon axle-boxes has been in use for many years at Pretoria, and is capable of producing seventy-two moulds per day for axle-boxes, or 216 moulds for other articles. The brassfoundry is adjacent to the ironfoundry, and is equipped with three portable Morgan tilting furnaces of 300 lb. capacity, three stationary furnaces, and two reverberatory furnaces. Castings of various metals and alloys are produced daily in great quantities, such as brass, bronze, white metals and aluminium. The white metal is cast into ingots of uniform size and shape. These ingots are formed in chills, and each one has an identification mark according to the mixture of metal. The Pretoria foundry produces all the white metal required for the different workshop centres. This practice has been adopted with a view to maintaining the various white metals in use up to standard mixture. Standard mixtures are laid down for locomotive bearings, carriage and wagon bearings, and metallic packing of locomotives. In each case the mixture has been arrived at after years of experience and experimenting. Aluminium castings are manufactured for the motor section, which has developed into a large branch of the Railway Administration's service. All furnaces, with the exception of the reverbatory furnaces, are coke fired. The pattern shop is well equipped with patternmakers' tools and machines.

Rhodesia's Copper Mines.

The Bwana M'Kubwa mine started to produce copper towards the end of last year. The first output will probably be announced in a few days, and from then onwards regular monthly returns are to be anticipated. Bwana M'Kubwa has now become a big industrial factor in South Central Africa, and much interest attaches to the company's future operations. The initial production aimed at is 10,000 tons per annum, but that should prove to be only the beginning of a larger output. Other rich copper producers are also likely to be in operation at a comparatively early date. Rich copper resources are now proved to exist, particularly in the stretch of country running along the Rhodesia Congo border, wherein promising properties are now being opened out.

Southern Rhodesia is also coming to the front, and the Copper Queen, Copper King, Gondia and other properties lying between the Sanyati and Umnia rivers and Sinoia and the Alaska Mine, in the vicinity of the last-named place, are all big potential copper producers. These mines are held by the Southern Rhodesia Base Metal Corporation, the prospects of which are regarded as being very promising. The ores at these mines, although of different kinds, are all considered to be very amenable to treatment by differential flotation methods. Plants are being installed and with a large total ore tonnage it is confidently expected that in five years' time the metal outputs of these mines will run into many thousands of tons of copper per annum.

Quick Coaling at Durban.

A remarkable coaling record was put up at Durban Harbour on December 4th and 5th, when altogether 23,825 tons of coal were shipped. The conveyor belt contributed nearly 14,000 tons to the total. The extension of the conveyor belt, recently made, has rendered it possible for two ships, berthed alongside, to be served by it. The belt is believed to be one of the longest in the world. The total weight shipped during the week was also impressive, amounting to 71,634 tons, which is the highest since early in 1922.

Railway Matters.

THE London and North-Eastern ceased on Monday last to run trains between Marylebone and the Metropolitan and Great Central Joint Committee's station at Watford. All the service is now given by the Metropolitan, which company is providing more trains.

A RECORD has just been established in the number of suggestions from the staff accepted by the authorities of the Underground Company. Out of 433 ideas sent in during a recent month 47, or 11 per cent., were accepted. The previous best record was 40 acceptances in 1920.

IN our issue of September 10th we recorded that a string of empty carriages, stabled in a siding on the Rishworth Branch of the former Lancashire and Yorkshire Railway, had run back and several been derailed and damaged at the catch points at Watson's Crossing Station. Now we have to record that the same thing happened on Friday last when 200 coaches were involved and twelve were damaged.

IN connection with the reconstruction and enlargement of the station at Dover Priory, the Southern Railway is removing the locomotive depôt there to near Dover Marine Station, where a sea wall is, in anticipation, being built. In connection with that work the borough engineer has put before the Dover Corporation a proposal that the work be continued as a marine walk along the whole extent of the beach to Shakespeare Cliff.

THE London and North-Eastern Railway is enlarging its marshalling yard at Whitemoor, near March, on the former Great Northern and Great Eastern Joint Line, at a cost of £300,000. There are to be ten reception roads, and forty marshalling sidings to accommodate 4000 wagons. Shunting will be done by gravitation, with points actuated electrically. This suggests to us that coal traffic from Doncaster and north thereof to the south will be taken off the former Great Northern main line and placed on the Doncaster–Spalding route.

SLOANE-SQUARE Station, on the Metropolitan District Railway, is to be modernised. The station buildings are to be in Portland stone and escalators and passimeters will be provided. The platforms are lower than usual, as clearance had to be given when the line was made for the conduit to carry the branch of the old Westbourne, in the bed of which the station was built. For that reason the platforms are at present reached by a double flight of stairs, with an intermediate landing. That arrangement will be dispensed with when the escalators have been provided.

THE Great Western Railway has renewed its publicity campaign for popularising the 20-ton mineral wagon. A rebate of 5 per cent. on the railway charges is made whenever that capacity of wagon is used and 1¼d. per ton off the tipping and weighing charges at the docks. One of the activities of the engineer's department of the railway company has been the adoption, construction and reconstruction—in conjunction with the chief mechanical engineer's department—of hoists and tips in connection with the larger wagons. The work at Newport, Cardiff and Port Talbot has been finished, whilst at Swansea it approaches completion, and at Penarth good progress has been made.

THERE has been a considerable amount of correspondence in the Press of late as to the want of punctuality of business trains. The officers of the railway companies, when seen on the subject, put the blame on the imported coal and say that when, in a month or so, it has been used up all will be normal. That answer does not, however, reply to the charge made in some cases that certain business trains have for years regularly run late. That is a fact that is awkward—and possibly hard—to explain, and we would like to offer the suggestion that the reason is to be found in the greater number of season ticket holders, who, of course, are the main users of business trains. When we say that in 1925 there were 50 per cent. more third-class season ticket holders than in 1913, it will be appreciated that the stoppages at stations must necessarily be of a longer time than formerly.

THE report by Sir William Hoy, on the operation of the railways of South Africa during the year ended March 31st last, has just reached us. It shows that the receipts were £24,151,409, and the expenditure £18,735,235, which left net receipts of £5,416,082. After deducting interest on the £126,029,725 capital expended, there was a surplus to be carried to the revenue distribution account, of £1,083,999. The receipts were 11·05 per cent. higher than in 1924–25, and the expenditure was 12·22 per cent. higher. The ratio of expenditure to receipts was 77·05. The number of passengers carried and the volume of the goods traffic were the highest yet recorded. Compared with 1909—the year before Union—the number of passengers showed an increase of 170·59 per cent., and the earnings therefrom one of 116·37 per cent. Mention is made of the opening, on June 25th, 1926, of the full electrical services on the 175 miles between Glencoe and Pietermaritzburg. It is too early as yet to speak of the results, but one of the passenger trains which formerly required 8 hours 17 minutes for the 175 miles run is now handled in 7 hours 47 minutes—a saving of 30 minutes. On the reverse journey the saving is 37 minutes. Goods trains used to be limited in load to from 820 tons to 1000 tons, and took 16 hours 30 minutes. Three electric units, manipulated by one driver and an assistant, now convey 1500 tons throughout in 10 hours 15 minutes. A dynamometer car will shortly be added to the equipment of the administration. It has been decided to obtain twenty-five first-class saloons on the articulated principle for use on the Union Limited and Union Express trains. To afford greater security against the accumulation of silt at Colenso power-house the solid weir is being replaced by a barrage which will consist of four steel gates, each 40ft. clear span and one gate 10ft. clear span. Coaches for use in the Capetown suburban area electrification are being delivered at the Salt River workshops. The length there to be changed from steam operation is 65·3 miles. Automatic signalling with day-colour light signals is being provided between Capetown and Wynberg on that work, and an all-electric signal-box at Capetown will replace two mechanical boxes.

Notes and Memoranda.

THE recoverable lead contained in ore mined in the United States in 1926 was about 672,000 short tons, as compared with an output of 684,073 tons in 1925. The production of refined copper was 1,738,000,000 lb., as compared with 1,683,000,000 lb. in 1925.

PRESIDING at the dinner of the Association of Engineers in Calcutta, Mr. McGlashan, Chief Engineer, Port Commissioners, mentioned that India has, down to recent times, begun to suffer from a surfeit of self-termed engineers, who are neither qualified by training nor actual experience, nor by pseudo degrees from America and Europe to be relied upon in the engineering profession.

IT is said that Santa Barbara County, California, has accessible deposits of oil-soaked sands and shale more than 1000ft. thick. The oil sand and "tar-spring" deposits of Alberta, Canada, all of which may be considered accessible, are estimated to contain more than 250,000,000,000 barrels of oil. These are only two of the numerous accessible deposits in various parts of the world.

BY means of a new method, devised by a Berlin engineer, household garbage is separated and sifted and all cellulose ingredients subjected to a special treatment, after which they can be turned either into guncotton or artificial silk. By distilling the remaining refuse, potato peelings, wood and so forth, tar, charcoal and acetic acid may be produced. A big plant for the disposal of garbage by this method is under construction in Berlin.

ACCORDING to the American Trade Commissioner in Berlin, the coal liquefaction plant being erected by the I. G. Farbenindustrie A.-G., on a site contiguous to the Leunawerke at Merseburg, will embrace twenty-three large new buildings. In ten of those buildings the fine coal and dust coal (lignite) will be "liquefied." Special apparatus will be employed to recover hydrogen. In addition to the "oil from coal" plant the Leunawerke is also constructing a new calcium nitrate plant, two gas tanks, each of 2800 cubic metres capacity, new silos and a new cooling tower.

A NEW pig iron which is manufactured in Norway is being put on the market by a London firm. It contains an exceptionally high percentage of certain alloys, such as vanadium and titanium, which two metals bring about improvement in the physical properties of the resultant steel altogether out of proportion to the small amount present. The analysis of this iron, which is branded "Lilleby No. 1," is as follows:—Vanadium, 0·5 minimum or 0·6 minimum: titanium, 0·5; silicon, 0·8 to 1·2; sulphur, 0·001 to 0·003; phosphorus, 0·07; manganese, 0·1 to 0·2; and aluminium, 0·1 to 0·2 per cent.

IN general, the electric field in the atmosphere becomes, according to an article in *Comptes Rendus* by Monsieur T. Idrac, less with increasing altitude. The author gives as the mean of his results 10·4 volts per metre at 4000 m.; 5·6 volts per metre at 6000 m.; and 2·3 volts per metre at 8000 m. From the three balloons that entered the isothermal layer of the atmosphere, it was discovered that, at the lower limits of it the field assumed a considerable value amounting to 30 or 40 volts per metre. The one balloon that reached 20,000 m. showed that above 16,000 there was a regular decrease, 12 volts per metre at 16,000 m., 5 volts per metre at 17,000 m., and 1·2 volts per metre at 19,000 m.

FOR the past two decades Canada has been the main source of the world's supply of cobalt. Ores, concentrates and residues from the cobalt district of Ontario are shipped to the Deloro Smelting and Refining Company at Deloro, Ontario, and to United States and European smelters. Cobalt is marketed in the form of black oxide containing about 71 per cent. cobalt, as grey cobalt oxide containing about 76 per cent. cobalt, as various salts of cobalt, and as metal. Computed as the sum of the cobalt contained in metal, oxides, salts, ores, concentrates and residues marketed during the period, the production of cobalt in the first half of 1926 amounted to 384,034 lb., as against 590,087 lb. in the first half of 1925.

Two new leaching methods for the recovery of molybdite from the ore have been tested by the American Bureau of Mines and are believed to have commercial possibilities. In one method the procedure is to extract the ore with hot soda solution, acidify with sulphuric acid, add a small amount of sodium acetate, and digest with lead sulphate. Molybdenum is completely precipitated as lead molybdate, which can be converted to molybdenum trioxide. In the other process the ore is extracted with warm dilute sulphuric acid and the free acid completely neutralised with scrap iron. Molybdenum is completely precipitated as a hydrate of molybdenum dioxide nearly pure. By treating the hot roasted ore with chlorine practically complete separation of the molybdenum from all other ore constituents is obtained in one operation. The distillate is quite pure and is easily converted to molybdenum trioxide or calcium molybdate. The consumption of chlorine need not be heavy and the regeneration of chlorine for repeated use seems possible.

QUEBEC is on the threshold of becoming a rival of Ontario and British Columbia as a metal-producing province. Up to the present, 90 per cent. of the province's annual mineral production, of a total value of 25 million dollars, has been of non-metallic minerals, such as asbestos, mica, magnesite, feldspar and building materials. Recent discoveries of copper, gold and zinc are, however, likely to make great changes. A branch railway line, 50 miles long, has been completed into the centre of the Rouyn area of North-West Quebec, and a 1000-ton smelter is in course of construction. Rouynville, which did not exist two years ago, is a flourishing town, and another town, Noranda, has just been incorporated. In the Rouyn area 250 miles of roads have been constructed by the Provincial Government and the mining companies directly interested. Mine machinery and equipment is being hurried to the district by the new railway line, and work which has been held up owing to transportation difficulties is now proceeding apace. The first shipment of bullion from the Rouyn gold camps is expected before the winter of 1927.

Miscellanea.

THE Dawsholm gasworks, Glasgow, is to be extended at a cost of £245,063.

PART of the old waterworks buildings of the Slough Urban Council is to be converted into a factory.

THE municipality of Swellendam, South Africa, proposes to expend £15,000 on an electric lighting scheme.

THE projects for manufacturing artificial silk in Japan have, according to the *Chemical Trade Journal*, been definitely abandoned.

A LARGE factory for the manufacture of caustic soda and chlorine is to be put up by the Mount Lyell Company near Sydney, Australia.

ACCORDING to the *Natal Mercury*, the proposition to construct two deep-water berths, 900ft. and 1200ft. long, at Cato Creek, Durban, has been revived and will probably be proceeded with.

DURING last year 266,000 horse-power was added to the hydro-electric development of Canada, bringing the total installation up to 4,556,000 horse-power. Other schemes now in course of construction will add 1,700,000 horse-power to the total.

THE Sub-Committee of the Glasgow Electrical Department has recommended the acceptance of a proposal to fit an apparatus for providing an auxiliary hot water heating system in 180 new electric houses at Kelvindale as part of their standard equipment.

THE Bramtone factory of Crosse and Blackwell, Ltd., has been purchased for the manufacture of artificial silk. The contract for the supply of necessary machinery, valued at £400,000, has been secured by John Hetherington and Sons, Ltd., licencees of the Kohorn patents in this country.

IN 1925 the copper ore raised by the Union Minière du Haut Katanga exceeded 2,000,000 tons. The work that is being carried on at present includes the erection of reverberatory furnaces with a capacity of 30,000 to 40,000 tons of copper per annum and an increase of 30,000 kilowatts in the power station.

IT is proposed to construct in Durban North what is described as the longest concrete bridge erected by private enterprise in the Union of South Africa. The total length of this bridge will be 540ft., comprising five 82ft. and two 45ft. spans, the width being 18ft., with a 4ft. 6in. footpath on each side. The maximum height above the ground will be 60ft.

IT is announced in the Board of Trade *Journal* that a British firm has secured orders to the value of £200,000 on competitive tenders from the Commonwealth of Australia, Postmaster-General's Department, for six automatic telephone exchanges in the Brisbane area. Three exchanges, also of the same firm's manufacture, are already in operation.

WITH the object of extending the scope of the Calgary branch of the Canadian Institute of Mining and Metallurgy it was decided at a recent meeting of the Institute to include a Petroleum Branch. Mr. J. H. McLeod was elected chairman, and Mr. C. W. Dingman, of the Department of the Interior, vice chairman, with Mr. B. L. Thorne secretary.

THE first of the three lock gates for the big new lock that is now in course of construction at the North Sea Port of Ijmuiden, has been successfully launched at Rotterdam, and will be towed to its final destination. The new lock at Ijmuiden will be the largest in the world, and will have twice the capacity of the Gatun Lock on the Panama Canal. The gate is 180ft long, 28ft. thick, and 66ft. deep, and weighs over 1000 tons.

THE Indian Government Telegraph Department has been making active experiments with the newly completed telephone connection between Calcutta and Bombay. The new line, which is from Bombay to Delhi and then on to Calcutta through Agra and Lucknow, is nearly 1800 miles in length. It is understood that preliminary experiments have proved entirely satisfactory as far as is possible in the initial stage.

REPORTS reaching Winnipeg, and published in *Canada*, indicate that oil has been struck six miles north of Grandview. The No. 1 well on the Balak lease is reported to be flowing 35 to 40 barrels per day. Partial tests indicate that the oil is about 42 per cent. gravity, with high gasoline content and paraffin base. The well was only spudded in about six weeks before oil was found, having been struck at the shallow depth of less than 1000ft.

A SELECT Committee of the Indian Legislative Assembly is engaged on the examination of the Steel Protection Bill. The discussion in the Committee last week centred round the question of differential duties on imports, and it is believed that the Government will be pressed to insert a clause enabling the Government of India to raise the basic duties if the cost of production of British steel at any time during the seven years' protective period goes down.

IN view of the successful petroleum operations at Infantas, in Colombia—although the shipment of oil started as recently as last March—and of the increasing production of the Andean National Corporation's wells, it has become necessary to duplicate the 360-mile pipe line. The second pipe, like the first, will be 10in. in diameter, and the pipe will be in 20ft. instead of 40ft. lengths as in the first pipe, that length having been found in practice to be inconvenient.

THE statement was recently made by the Mayor of Pretoria that it could now be made public that the Government was establishing an iron and steel industry in Pretoria. A company would be floated with a capital of three or four million pounds, in which the Government would have a controlling interest. He observed that the efforts made for many years to obtain capital in England, the Continent or America had failed, owing to the antagonism of the European ironmasters. Pretoria was the only centre in which the industry could be established economically on a large scale, as it had millions of tons of fair grade iron ore on town lands which were to be given practically gratis to the company.

THE REID-MACLEOD STEAM TURBINE LOCOMOTIVE

THE NORTH BRITISH LOCOMOTIVE COMPANY, LTD., GLASGOW, ENGINEERS

(*For description see page* 118)

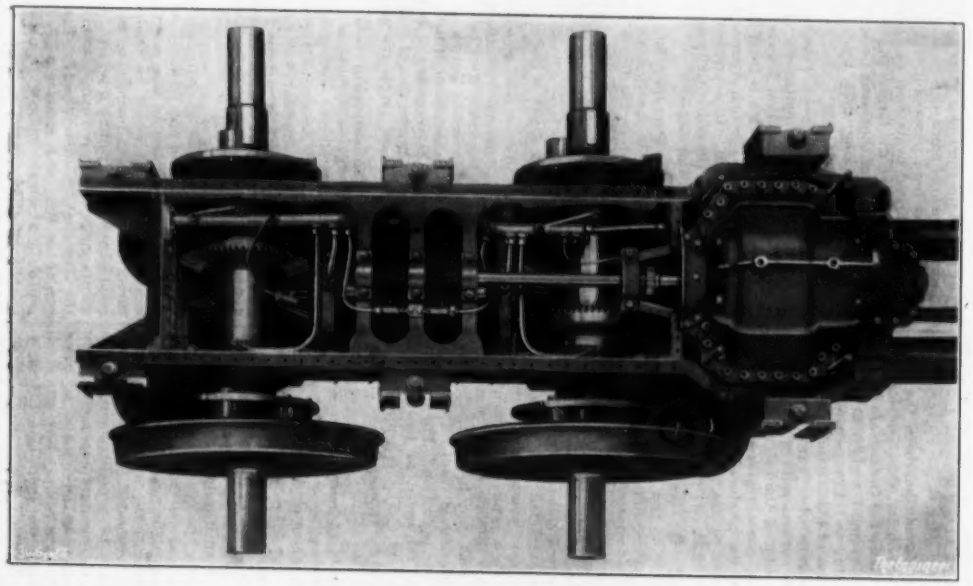


FIG. 8—HIGH-PRESSURE DRIVING UNIT

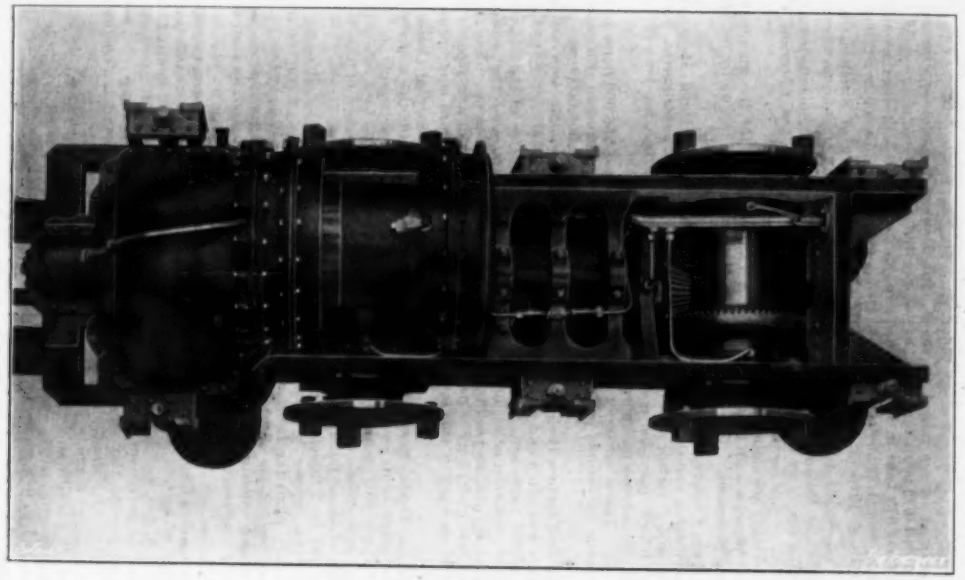


FIG. 9—LOW-PRESSURE DRIVING UNIT

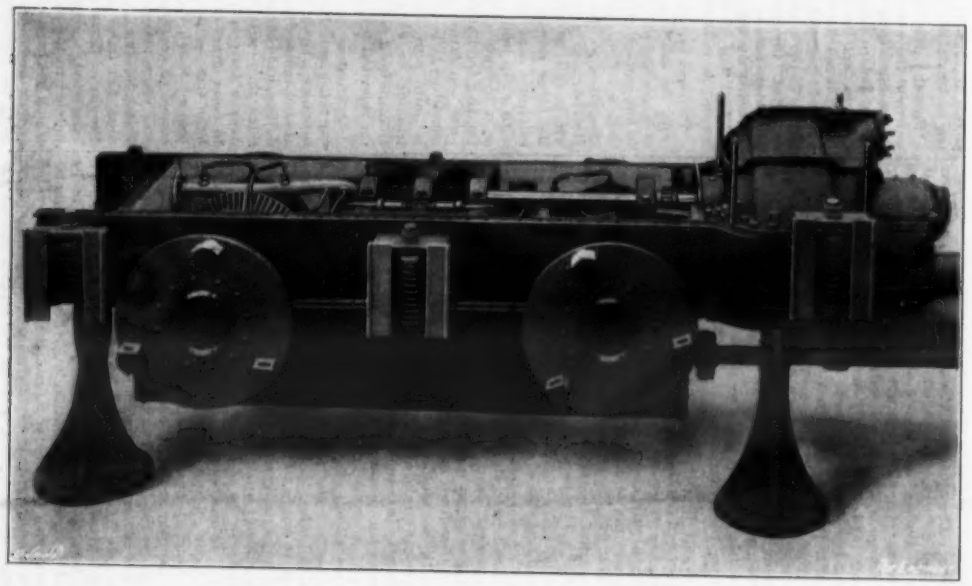


FIG. 10—SIDE VIEW OF HIGH-PRESSURE DRIVING UNIT

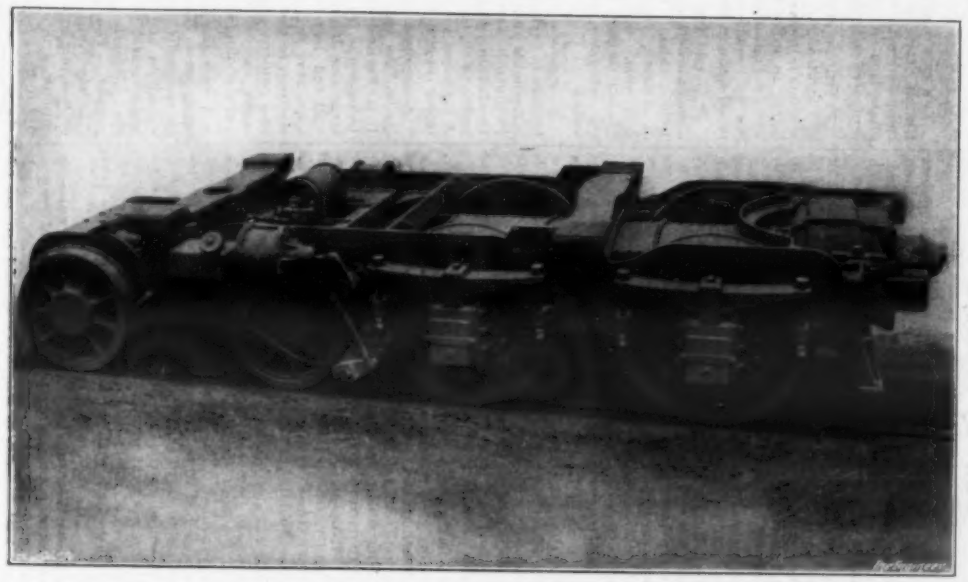
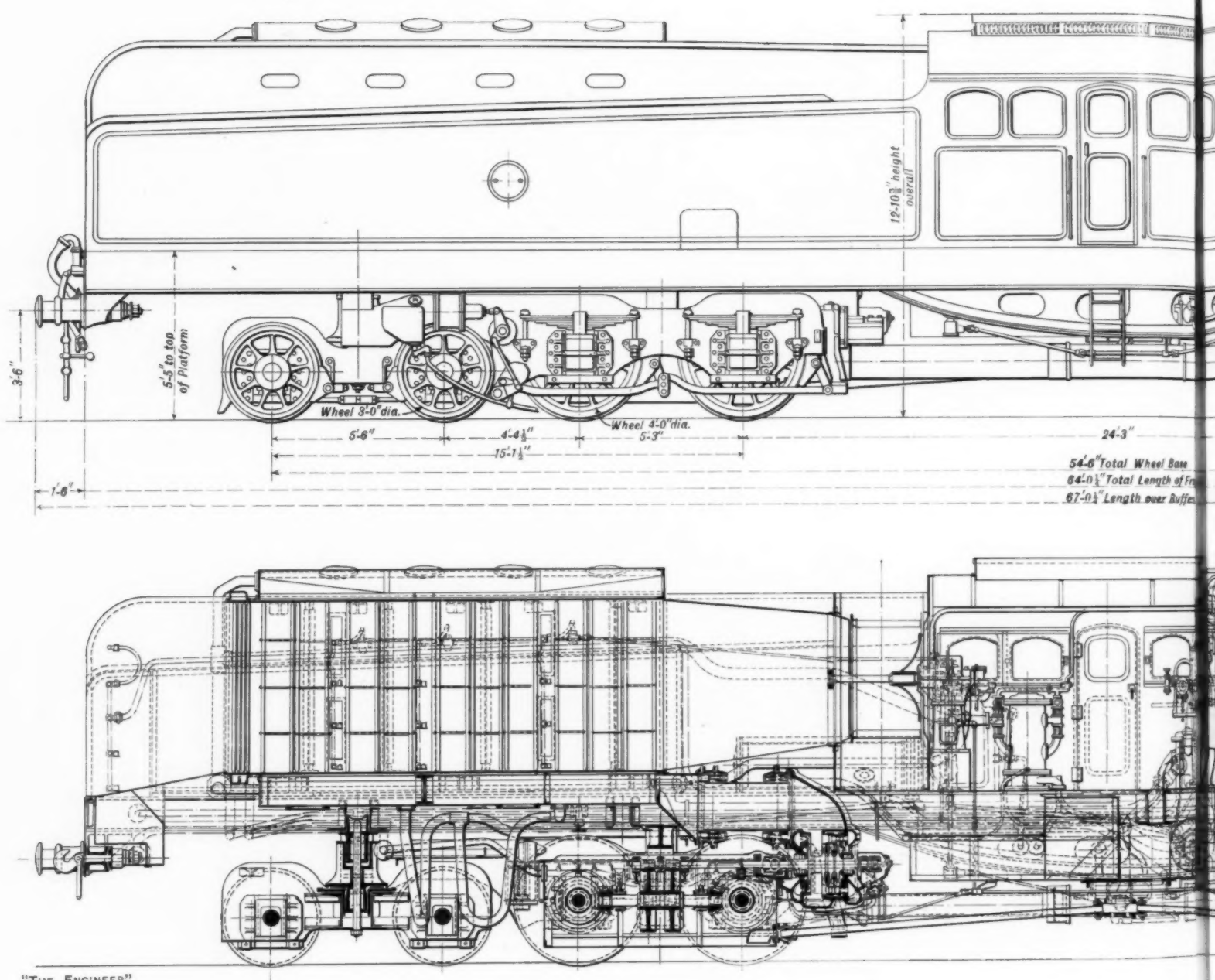


FIG. 11—GENERAL VIEW OF HIGH-PRESSURE DRIVING BOGIE

UNIV. OF MICH.

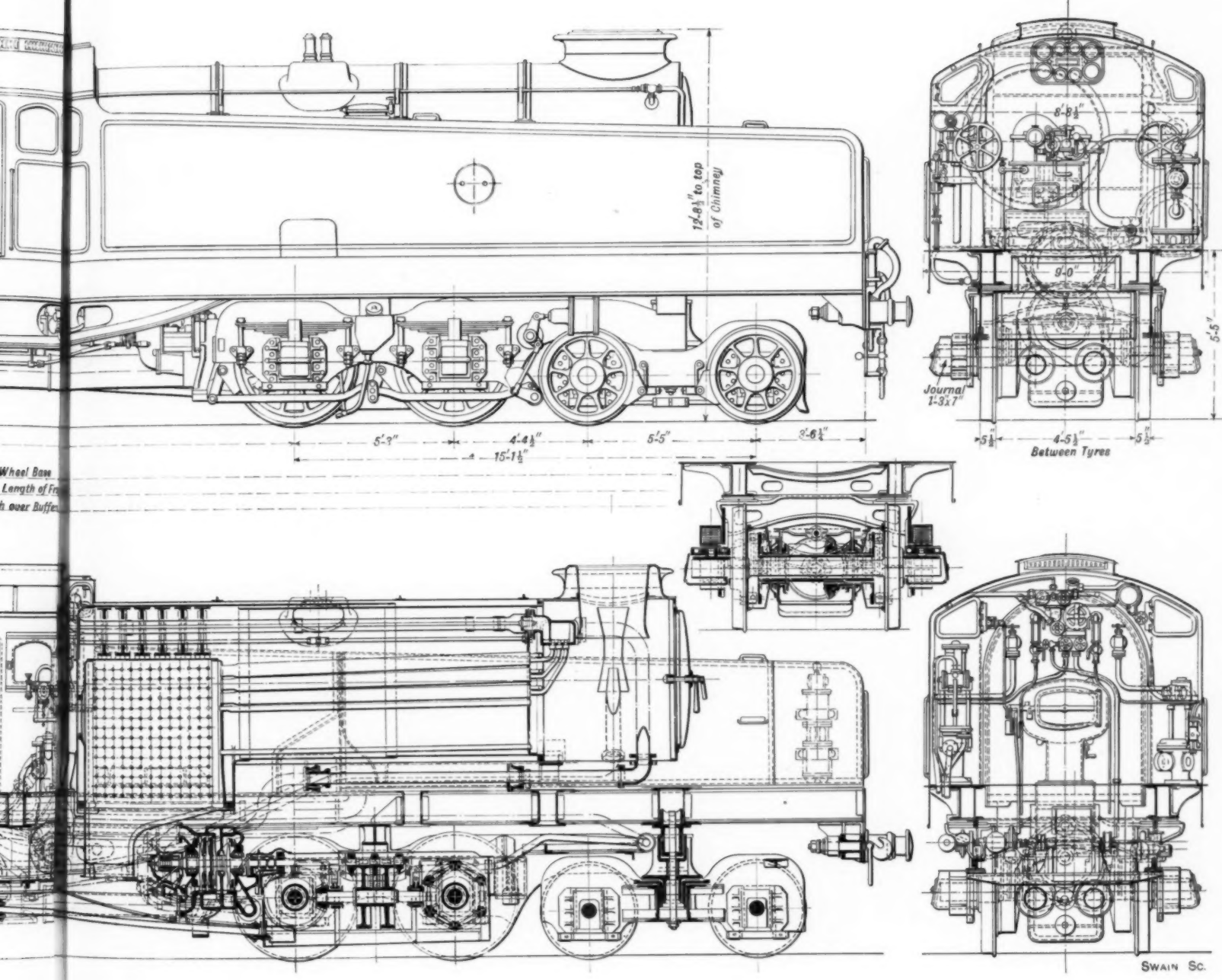
REID-MACLEOD STEAM

NORTH BRITISH LOCOMOTIVE CO



TEAM TURBINE LOCOMOTIVE

OTIVE COMY, LTD., GLASGOW, ENGINEERS



Wheel Base
Length of Fr
h over Buffe

SWAIN SC.

UNIV. OF MICH.

AGENTS ABROAD FOR THE SALE OF

The Engineer

BUENOS AIRES.—MITCHELL'S BOOK STORE, 576, Cangallo.

CHINA.—KELLY AND WALSH, Limited, Shanghai and Hong Kong.

EGYPT.—CAIRO EXPRESS AGENCY, near Shepheard's Hotel, Cairo.

FRANCE.—BOYVEAU AND CHEVILLET, Rue de la Banque, Paris. CHAPELOT AND CIE., 136, Bld. St. Germain, Paris.

GERMANY.—FRITZ REHFUS, Blumenthalstrasse, 10, Cologne.

BELGIUM.—W. H. SMITH AND SON, 78/80, Rue du Marché-aux-Herbes, Bruxelles, and 44, Rue Joseph II., Ostend.

INDIA.—A. I. COMBRIDGE AND CO., Bombay; THACKER AND CO., Limited, Bombay; THACKER, SPINK AND CO., Calcutta.

ITALY.—MAGLIONI AND STRINI, 307, Corso, Rome; FRATELLI TREVES, Corso Umberto 1, 174, Rome; FRATELLI BOCCA, Rome; ULRICO HOEPLI, Milan.

JAPAN.—MARUZEN CO., Tokyo and Yokohama.

AFRICA.—WM. DAWSON AND SONS, Limited, 7, Sea-street (Box 49), Capetown.
C. JUTA AND CO., Johannesburg, East London, and Grahamstown.

AUSTRALIA.—GORDON AND GOTCH, Limited, Melbourne, Sydney, Brisbane, and Perth, &c.
MELVILLE AND MULLEN, Melbourne.
ATKINSON AND CO., Gresham-street, Adelaide.

CANADA.—DAWSON, WM., AND SONS, Limited, 87, Queen-street East, Toronto.
GORDON AND GOTCH, Limited, 132, Bay-street, Toronto.
MONTREAL NEWS CO., 386–388, St. James-street, Montreal.
TORONTO NEWS CO., 42, Yonge-street, Toronto.

CEYLON.—WIJAYARTNA AND CO., Colombo.

JAMAICA.—EDUCATIONAL SUPPLY CO., Kingston.

NEW ZEALAND.—GORDON AND GOTCH, Limited, Wellington and Christchurch; UPTON AND CO., Auckland; J. WILSON CRAIG AND CO., Napier.

STRAITS SETTLEMENTS.—KELLY AND WALSH, Limited, Singapore.

UNITED STATES OF AMERICA.—INTERNATIONAL NEWS CO., 83 and 85, Duane-street, New York; SUBSCRIPTION NEWS CO., Chicago.

SUBSCRIPTIONS.

THE ENGINEER can be had, by order, from any newsagent in town or country, at the various railway stations; or it can, if preferred, be supplied direct from this office.

Half-yearly (including index number) .. £1 12s. 6d.
Yearly (including two index numbers) .. £3 5s. 0d.

If credit occur, an extra charge of two shillings and sixpence per annum will be made.

Foreign Subscriptions will be received at the rates given below. Foreign subscribers paying in advance at these rates will receive THE ENGINEER weekly and post free. Subscriptions sent by Post Office Order must be made payable to THE ENGINEER and accompanied by letter of advice to the Publisher.

THIN PAPER COPIES.	THICK PAPER COPIES.
Half-yearly .. £1 11s. 6d.	Half-yearly .. .. £1 13s. 9d.
Yearly .. .. £3 3s. 0d.	Yearly .. .. .. £3 7s. 6d.

(The difference to cover extra postage.)

Canadian Subscriptions—
Thin paper edition .. .. £2 18s. 6d. per annum.
Thick paper edition .. £3 3s. 0d. ,,

**** READING CASES, *to hold two copies of* THE ENGINEER, *cloth sides and leather backs, can now be supplied at 4s. 9d. each, 5s. 3d. post free.*

ADVERTISEMENTS.

**** **The Charge for Situations Open and Wanted Advertisements of four lines and under is four shillings, and one shilling per line for each additional line up to one inch. When an advertisement measures an inch or more the charge is twelve shillings per inch. The rates for all other classes of advertisements, other than those mentioned above, are included in "THE ENGINEER DIRECTORY," which is sent post free on application. All single advertisements from the country must be accompanied by a remittance in payment. Alternate advertisements will be inserted with all practical regularity, but regularity cannot be guaranteed in any such case. All except weekly advertisements are taken subject to this condition.**

Small Advertisements cannot be inserted unless delivered before TWO o'clock on Thursday afternoon (the day before publication). ALTERATIONS to STANDING ADVERTISEMENTS must arrive not later than THURSDAY of the week preceding publication.

Letters relating to Advertisements and the Publishing Department of the Paper are to be addressed to the Publisher, all other letters to be addressed to the Editor of THE ENGINEER.

THE ENGINEER DIRECTORY.

This Directory, which is published annually in the interests of advertisers in THE ENGINEER, may be obtained free of charge on application to the Publisher.

"THE METALLURGIST"—BINDING CASES.

Cloth Binding Cases for twelve issues (one year) .. .. 2s. 0d.
Subscribers' own copies, including cases, bound Cloth .. 4s. 0d.
Bound half roan 7s. 6d.

Postal Address, 35, Norfolk-street, Strand, W.C. 2.
Teleg. Address, "Engineer Newspaper, Estrand, London."
Telephone Nos. 2256, 2257 Central.

PUBLISHER'S NOTICES.

*** With this week's number is issued as a Supplement a Two-page Plate of the Reid–MacLeod Steam Turbine Locomotive. Every number, as issued by the Publisher, contains a copy of this Supplement, and Subscribers are requested to notify the fact should they not receive it.*

*** If any Subscriber abroad should receive* THE ENGINEER *in an imperfect or mutilated condition, he will oblige by giving prompt information of the fact to the Publisher, with the name of the Agent through whom the paper is obtained. Such inconvenience, if suffered, can be remedied by obtaining the paper direct from this office.*

TO CORRESPONDENTS.

*** All letters intended for insertion in* THE ENGINEER *or containing questions should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications,*

*** We cannot undertake to return drawings or manuscripts; we must therefore request correspondents to keep copies.*

By arrangement with Reuter's Engineering Service, **The Engineer** *contains the latest news from all parts of the world which is likely to be of interest to engineers,*

Contents.

THE ENGINEER, February 4th, 1927.

	PAGE
A SEVEN-DAY JOURNAL	117
THE REID-MACLEOD STEAM TURBINE LOCOMOTIVE. (Illus.)	118
SOME PRACTICAL NOTES ON SOLDERING AND WELDING ALUMINIUM. (Illus.)	121
COILERS FOR COLD STRIP ROLLING MILLS. No. II. (Illus.)	123
SHIP PROPULSION RESEARCH	125
MANCHESTER ASSOCIATION OF ENGINEERS	125
THE USE AND ECONOMY OF HIGH-PRESSURE STEAM PLANTS. (Illus.)	126
SOUTH AFRICAN ENGINEERING NOTES	128
RAILWAY MATTERS	129
NOTES AND MEMORANDA	129
MISCELLANEA	129
LEADING ARTICLES—	
Expert Evidence	131
Gas Producers for Motor Vehicles	131
FOREIGN TRADE AND TARIFFS	132
LITERATURE	133
LETTERS TO THE EDITOR—	
The Newton Bi-centenary	133
The Largest Passenger Locomotive	133
Science in the Foundry	133
Unemployment	133
TEMPERATURE CONDITIONS IN REFRIGERATED HOLDS	134
STEAM BOILER WAGON FOR HEATING ELECTRIC TRAINS. (Illus.)	134
THE "ORTSO" AND ITS MODIFICATIONS FOR USE AS A PHONOSCOPE. (Illus.)	135
LARGE TRANSFORMERS. (Illus.)	135
PULLMAN CARS FOR THE CONTINENT. (Illus.)	136
A HOPPER COOLED OIL ENGINE. (Illus.)	137
APPLICATIONS OF POWER ON GASWORKS	137
SIXTY YEARS AGO	137
WORK HARDENING PROPERTIES OF METALS. (Illus.)	138
PERSONAL AND BUSINESS ANNOUNCEMENTS	140
PROVINCIAL LETTERS—	
The Midlands and Staffordshire	141
Lancashire	141
Sheffield	142
North of England	142
Scotland	143
Wales and Adjoining Counties	143
CURRENT PRICES FOR METALS AND FUELS	144
FRENCH ENGINEERING NOTES	145
BRITISH PATENT SPECIFICATIONS. (Illus.)	145
FORTHCOMING ENGAGEMENTS	146
CONTRACTS	146

TWO-PAGE SUPPLEMENT—REID-MACLEOD STEAM TURBINE LOCOMOTIVE.

DEATHS.

On January 16th, at his home, W. Y. FLEMING, senr., managing director of Fleming and Ferguson, Ltd., of Paisley.

On January 29th, at 43, Fairfield-road, Old Charlton, S.E. 7, WILLIAM CHARLES COPPERTHWAITE, late chief assistant engineer, London County Council, age 65.

THE ENGINEER.

FEBRUARY 4, 1927.

Expert Evidence.

IN the course of the case of Graigola Merthyr Company, Ltd., *v.* Swansea Corporation, the hearing of which was begun on November 3rd before Mr. Justice Tomlin and is not yet concluded, the learned judge expressed an interesting opinion about expert evidence. The action is one in which the plaintiff company is seeking to prevent the defendant Corporation from filling a certain reservoir on the ground that the water must inevitably percolate into and flood the plaintiff's coal mine. At the conclusion of the plaintiff's case, counsel for the plaintiff submitted that, in accordance with the usual practice, the defendants should not be allowed to call more than two expert witnesses. The defendants pointed out that this was a case in which expert evidence on different subjects was required. Thus they desired to call two witnesses as to the geology of the district, a mining engineer, an expert in matters relating to water, and one or two further experts on subsidiary matters. Mr. Justice Tomlin—whose ruling is set out in the *Weekly Notes* for January 22nd at page 30—pointed out that, while he attached no blame to any of the parties concerned, cases of this kind had become a serious burden to the Court. He said:—"It is due perhaps in part to the fact that there are very few aspects of life to-day which escape the cunning eye of science, so that in almost every case it is open to the parties to introduce a string of experts." He went on to say that if a litigant were left free to call all the evidence possible, it placed a weapon in the hands of persons of large resources. He therefore proposed to follow the rule that only two experts should be called unless there were special circumstances justifying a party in asking that more should be heard. In the present instance the plaintiff's case had taken twenty-six days and their two experts had been so fully heard that the issues had become plain and the nature of the defence had been clearly disclosed. This rule, however, would not prevent a witness being called on questions of fact, but in such case the examination should be confined to matters of fact and he should not be treated as an expert.

Those who are familiar with modern litigation will fully endorse the learned judge's observations upon the intrusion of science into the law courts. Indeed it may be that some people will be of opinion that in imposing any limitation upon the right to call experts his lordship may be placing an undue restriction upon the rights of a litigant. But it is conceived that when the true meaning of "expert evidence" and the proper functions of an expert witness are appreciated, no hardship can occur. What, then, is an expert witness? What is his true function in the administration of justice? These questions are by no means uninteresting to the engineer. As the learned judge took care to point out, a true and accurate knowledge of science and scientific principles may be essential for those who have to apply the law to the facts of particular cases; and although a learned judge may be a distinguished man of science—the names of Mr. Justice Grove and Lord Justice Fletcher Moulton at once come into the mind—it were impossible for all our judges to be endued with an all-embracing knowledge of these matters. In an old case (Folkes *v.* Chadd (1782) 3 Doug. 340) an action was brought for damages for cutting a bank erected for the purpose of preventing the overflowing of the sea. The bank had been cut, apparently, because it was alleged that its presence caused the choking up of a harbour. It was held that evidence of engineers as to the effect of the bank upon the harbour was admissible. The principle here enunciated has been persistently followed ever since. In the Admiralty Court, for example, the opinion of a nautical man on a question, formed upon a clear statement of all the facts, is always received in evidence. But an "expert witness," properly so called, ceases to be an expert as soon as he comes as witness to fact. So where an action is brought for damage occasioned by a nuisance, scientific evidence may be resorted to, not to establish the fact of the damage, but only to explain the causes of it. Expert witnesses are frequently summoned in patent cases. Indeed it is difficult to know how this kind of litigation could be conducted at all without their assistance. One of the functions of the expert witness, then, may be said to be to express an opinion as to what will or is most likely to happen—given a certain set of facts. His opinion may not be shared by another expert of equal standing in his profession, but it will be for the Court to decide which opinion to adopt in determining the issue in the case. In these circumstances it is manifest that an expert must base his opinion upon reasons which he can explain to the judge, and he is the best expert who can best explain himself to one who may have but an inkling of scientific knowledge. The faculty of clear and concise exposition of scientific principles is therefore desirable in an expert. If he has that faculty he will truly assist in the administration of justice, and espouse to the best advantage the cause of the party who has called him as a witness.

Although the learned judge did not say so, it is to be feared that the prolongation of the hearing of some modern law suits is due, to some extent, not to the number of experts called, but to the fact that an expert will sometimes mistake his function and attempt to advocate the cause. This is fatal. It tends to deprive his evidence of its real value. Whatever his private view may be as to the merits of the side by which he is retained, he must not express it. He is there to give an opinion upon the scientific bearing of certain facts already proved or as to the inference which he as a scientific man would draw from them. If he does more than that he wastes the time of the Court and rather impedes than assists the administration of justice.

Gas Producers for Motor Vehicles.

IT is now a good many years since producer gas was first advocated for the motive power of heavy vehicles, and much money and ingenuity have been expended in the endeavour to make a commercial success of the system. The gas producer has, however, as yet made little or no headway on the roads. Operating difficulties of various kinds have counterbalanced its lowness of fuel costs, and the steam wagon, with all its drawbacks, has established itself as a far more serious rival to the petrol lorry than has the gas producer vehicle. It is, nevertheless, probable that the last word has not yet been said on the subject. Every improvement in the petrol lorry, whether as regards flexibility of engine or perfection of transmission gear, operates equally to the advantage of the producer vehicle. Indeed, it does more; for it brings nearer the day when, engine and chassis being practically incapable of further improvement, attention will be directed more than ever to the fuel economy which may be secured through the gas producer system. In Great Britain the ideas of inventors have naturally turned to the production of gas

from coke or anthracite. These fuels are everywhere available in the country, and users are not controlled either as regards supply or price by any foreign organisation. It is possible that the efforts to use coke or anthracite have been among the causes which have led to non-success. With these fuels, too many problems at once had to be faced. At any rate, the development of road producers in France is proceeding along different lines. That country at the present time is very much concerned to render itself as far as possible economically independent. Its importation of petroleum and petroleum products places it, like Great Britain, in the position of having its road transport system and its military strength both liable to be paralysed by the action of foreign Powers. The weakness of the franc, moreover, tends to make the price of imported oil exorbitant. For these reasons we have, on one hand, active research directed towards the production of synthetic petrol and, on the other, practical efforts for the development of alternative sources of power. The improvement of the portable gas producer, so as to render it commercially available for road vehicles, is one of the directions in which relief is being sought. It is significant that at the last Salon des Véhicules Industriels in Paris, there were no less than eleven different makes of road gas producers on view, and such well-known firms as Panhard and Levassor, Berliet, and De Dion-Bouton have not hesitated to associate themselves with the movement. The fuel usually favoured in France is wood charcoal, though there were at the Salon two producers designed to gasify wood in its natural state. Anthracite and coke seem to be entirely out of favour. The great objections to wood charcoal are its bulkiness, friability and the ease with which it absorbs moisture. To avoid these a substance called Carbonite has been introduced in France. This is an agglomerated form of charcoal, produced from forest refuse, and sold in the form of little balls. It has five times the density of charcoal, and is much less easily crushed. As regards the development of power, 10 lb. of Carbonite are said to be equivalent to a gallon of petrol, though costing only about one-third the price.

There is as yet no great uniformity of practice as regards the design of producers. Most are of the down-draught type, no doubt on account of the ease with which this type lends itself to charging and to the gasification of the tarry matters in the fuel. Some makers line their producers with refractory material, while others do not. Practice differs also with regard to apparatus for preventing dust or tar in the gases from reaching the engine. There are mechanical dust arresters which depend on baffles for their action, boxes filled with iron shavings, chambers containing metal rings rendered sticky with oil, and filtering devices of various kinds. The gas is cooled as much as possible before reaching the engine, the process being generally recuperative, the heat of the gas being returned to the system either in the combustion air or in the water for the producer. The amount of ingenuity spent on purifying and cooling apparatus is very great, and the variety of the processes adopted may be taken either as evidence of the difficulty of the problem, or as proof of the number of solutions which are practicable. In any case, it bears witness to the activity with which the development of gas-driven vehicles is being pursued abroad. The use of producer gas, moreover, is by no means confined to the heaviest type of lorry. Messrs. Panhard and Levassor construct lorries down to 1·5 tons with this method of propulsion, the engine being rated at 12 H.P. It is the general practice to start the gas-driven vehicles with petrol, but they can be got away from cold in from three to five minutes after lighting up by the use of gas alone. They can, of course, be run on petrol in emergency, or in some designs on a mixture of petrol and gas. When running on gas alone, the power of the engine is reduced by about 25 per cent., resulting in a loss of speed of about 10 per cent., but the cost of fuel per mile is only about one-third of that when petrol is used.

The reasons for the development of the producer gas vehicle in France apply, though not perhaps quite to the same extent, in this country. We have raised the design of the steam lorry to a degree of perfection unknown on the Continent, and have thus attacked the fuel problem in a different way. But the fewness of steam-driven vehicles on the roads, in comparison with those driven by petrol, shows that the internal combustion engine has earned a popularity which nothing seems likely to surpass. It is inherently extremely efficient, and it is also easily handled and reliable. Its only drawback is that, under present conditions, it needs a fuel which places our road transport at the mercy of any event which might interfere with the importation of oil, though the indebtedness to foreign nations caused by such large purchases of oil is also a point to be considered in our national economy. With a home-produced fuel, even though the fuel were itself a manufactured product, we should be in a far better position. The ideal fuel from the national point of view would be coal or coke, but if ever this ideal is to be realised it seems likely that the first stages on the road will be by means of charcoal or some such product as Carbonite. Whatever the fuel is, it must be easily procurable by the owners of producer gas vehicles, otherwise any attempt to popularise such vehicles is bound to fail. The French manufacturers have not overlooked this point, and organised efforts are being made to render wood charcoal available at a reasonable price at all important centres. Side by side with this policy is the alternative one of designing producer plant which can run on wood, the latter needing no other preparation than being cut into pieces of less than 4in. cube, and being reasonably dry before use. We hope that the energy being displayed on the Continent in the development of producer gas vehicles will be marked by our own manufacturers. Small stationary producer plants, gasifying charcoal and wood, have been perfected by several British firms, being manufactured chiefly for export purposes. The experience already gained might be usefully employed in the design of light and simple portable plant for the propulsion of vehicles. A little of that practical kind of "research" which consists in making something and trying it, may prevent the subsequent rush to buy foreign designs, with all the loss of money, time, trade and prestige which this course involves. Simultaneously, the question of the provision of a suitable solid fuel must be considered. If it is to be charcoal, Carbonite, or some other prepared material, it must be on the market at the same time as the lorry. Perhaps the elaborate plant of our Fuel Research Board at Greenwich might be turned to useful account in this matter, though it is probably to private enterprise that we must look for a solution. As regards the development of the lorries themselves, a competition, open to vehicles of all nations, conducted on the lines of the R.A.S.E. suction producer trials twenty years ago, would probably do more than anything else to stimulate interest in their design and enlighten those concerned with road transport as to their merits and defects.

Foreign Trade and Tariffs.

(By our French Correspondent.)

THE opportunities of doing business with foreign markets have not been increased by the fluctuations in the economic situation of Europe, where a general lowering of purchasing power and the industrial development of all countries have had the inevitable result of raising up formidable fiscal barriers. A stage has been reached when the attempts to make each country as far as possible self-supporting have placed a serious check upon an interchange of goods. One effect of this policy is to raise prices whenever it is sought to exclude foreign goods and products. It is not sufficient to produce just what is needed for the home market, as that eliminates competition to the disadvantage of the consumer, and as, in many cases, the home consumption is inadequate to provide manufacturers with the means of producing, on an economical scale, the situation of industries that have been created under the protection of tariffs or a depreciated exchange rate, is necessarily precarious. Some industries in France and elsewhere, which were exceedingly prosperous during the period of currency inflation, when they were able to do a considerable export trade, now find themselves in difficulties. If goods are to be sold at a low price at home to stimulate consumption, they must be produced on a large scale to bring down production costs to a minimum, which usually means that there must be a large surplus for export. The only alternative is to lower the quality of the goods to permit of their being sold at lower prices, and in some cases this has been done to the detriment of the manufacturer's reputation. In the engineering trades abroad a sacrifice of quality is rarely attempted. The question therefore arises whether it is really good policy for a country to endeavour to produce all it needs without reference to the cost. In several cases the attempt has failed. In France those manufacturers who went in for the construction of textile machinery in the belief that they would be able to monopolise the home market had to admit themselves beaten. They imported sample machines which were copied to the smallest detail, but they lacked experience in manufacture and produced machines at prices that left them helpless to meet the competition of foreign makers who specialise in this branch of industry. So long as manufacturers were able to control foreign markets with the aid of a depreciated currency, they took little account of the situation in which they would be placed on a return to normal conditions. Of late, however, it has become perfectly clear that it will be difficult to develop new industries in France, except by a heavy production for export, and there can be little hope of selling abroad, without the artificial aid of a debased currency, unless there is reciprocity with foreign markets. The problem which is now confronting most foreign markets is whether new industries, which are not indispensable, should be adequately protected, or whether they should be sacrificed more or less for the benefit of national industries upon which the prosperity of the country depends. Means of extricating industry from this dilemma will be sought for during the discussion which will take place shortly upon the new Tariff Bill in France.

An instance of the unsatisfactory position in which industries are placed by fiscal legislation is provided by the slump in the French motor car trade. This branch was prosperous until recently, because the depreciated franc permitted makers to undersell their competitors abroad, despite the heavy duties imposed upon the importation of cars into foreign countries. When the franc appreciated on the international market, there was no corresponding appreciation at home, and production costs did not increase, except as the result of higher taxation, and imported raw material was actually cheaper. The result of the higher value of the franc abroad was that French goods became too expensive and could not be sold. This experience shows that, even with their present comparatively favourable conditions of manufacture, the French are unable to compete abroad against high import tariffs. An acceptance of this fact may do much to change the fiscal system in Europe. That it is recognised, is clear from the way in which the new Tariff Bill is being discussed. The existing French tariff dates from as far back as 1892, but it was greatly modified in 1910, and since then it has been increased by coefficients to adapt it to the declining value of the franc. It consists of a minimum scale which was applied to all countries enjoying the most favoured nation treatment and a general scale, which was just double, and could be reduced in the case of other countries, if necessary, in order to obtain reciprocal advantages. The Treaty of Versailles suppressed the most favoured nation treatment and left France free to act as she liked in the way of negotiating commercial arrangements. Of late, import duties have been increased, indirectly, mainly for the sake of revenue, and the situation has now reached a phase when it is extremely difficult to do foreign business at all. In a word, the tariffs all over Europe have become perfectly arbitrary, without any effort being made to insure equality of commercial and industrial conditions. When the work of establishing the new French tariff was started three or four years ago, the principle of the minimum and general scales was maintained, but the general tariff was to be three times that of the minimum. The whole classification of goods was to be readjusted in such a way that the duty on the weight of goods would represent what would be imposed if they were assessed according to their value. Since then the tariff has been entirely remodelled, and it will probably undergo many changes during its course through the Chamber of Deputies in the present session. The tariff is regarded at the moment less as a measure of immediate protection of industries than as a means of negotiation. The coefficients will, of course, be suppressed, and it is proposed to take the indices of wholesale prices every three months, and, if they should show an advance or a decline of at least 20 per cent., the import duties will be modified to a corresponding extent. At present those French industries, which live mainly on an export trade, cannot afford to be tramelled by tariffs that tend to close foreign markets to them, but, while perfectly aware that any policy of commercial or industrial isolation must prove a failure, an important section of the community firmly believes that the scheme of colonial development which it is hoped to carry out will allow of France achieving her great ideal of becoming entirely self-supporting.

The policy that may be evolved by France during the next few months must influence to a considerable extent the commercial relations of countries all over Europe. Whatever is done now can only be a compromise. There can be no question of bringing back an immediate prosperity to industry, and all that can be done is to facilitate a return to normal conditions of trade. A great obstacle to the attainment of this end is the profound conviction of most countries that prosperity can only depend upon purchasing as little as possible abroad and developing industrial activity at home. That is particularly the case with countries that formerly exchanged national products for foreign manufactured goods, and British firms were able to send their goods to those markets in return for all kinds of produce which were necessary to us. Now, foreign countries wish to sell their produce and manufacture their own goods. That involves a complicated problem which is still far from solution. It means a continuance of high tariffs, high prices at home, and a declension of foreign trade. In whatever way the situation is regarded the ten-

dencies are always in the direction of higher import duties. Impoverished States must obtain money, and, instead of being merely protective, the tariffs are regarded as a source of revenue. When France increased her import duties, Belgium retaliated by putting hers still higher. Germany raised her fiscal barrier partly as a means of bringing pressure upon France. Spain has imposed prohibitive duties for the protection of home industries, which can hardly be said to exist. All over Europe this economic war is being waged. While that war is pursued by States and by industrial interests, little is heard of the interests of commercial communities, which are entirely opposed to any system of exaggerated protection. In a general way, a country's prosperity depends as much on commerce as upon industry, and industry always profits from a development of commerce. The voice of the commercial community will be heard in the forthcoming debate upon the French Tariff Bill. It may moderate the tariff without removing its restrictive character, for the new fiscal legislatiom is purposely evolved to be of service as a means of negotiation, but as other countries may be tempted to follow that example in self-defence the modern conception of tariffs becomes absurd in its incoherence. The only hope for the future lies in an understanding amongst manufacturers in different countries if such an understanding is possible. The invitation which has been sent by the Federation of British Industries to French manufacturers to meet in London for the discussion of questions affecting their common interests, is a step which may have important consequences in the future. It is to be hoped that the results of that meeting will justify the holding of other gatherings where all the leading industries will be represented and where it will be possible to establish economic truths that can alone bring back some measure of prosperity to foreign trade.

Literature.

The Chemistry of Cellulose and Wood. By A. W. SCHORGER, Ph.D. International Chemical Series. London: McGraw-Hill Publishing Company, Ltd. 1926.

THIS book will be found to be an exception to the rule by the reader who is a chemist, as its title describes its contents. It confines its attention to the chemistry of cellulose and to that of wood, and it is evidently written by a chemist, and excellent withal. The departures into physics, botany and other sciences are limited to the strictly necessary, thus enabling the author to give more facts about his actual subject than probably any other book since the appearance of Cross and Bevan's classic. A very large percentage of the contents is devoted to the chemistry of wood and wood cellulose, and consideration has been given to the most up-to-date discoveries and methods of working, as viewed by the chemist *ex professo*. An equally well-written book on the mechanical and engineering part of wood pulp manufacture added to this one would make a useful library for a modern pulp factory's laboratory. The literature references are very numerous and appeared to the reviewer a bit irksome at first, but having occasion to verify some of them, he found them critically chosen. With regard to artificial silk, the author has been wise enough to limit his attention to generalities, and that is praiseworthy caution, as the silk manufacture starts where the chemistry ends. At the end of the book the practical worker on the subject will find a useful *résumé* of analytical methods, with working details, wherever such are necessary.

Although this book is written in a most lucid style and easily readable, it is not in any way intended for the amateur chemist. Still, it shares with the classical German text-books on chemistry the property of being concise enough to be safe in the hands of the advanced student. In this case, the influence of German models may be direct, but such a similarity is not uncommon in the American chemical literature. In the main, it consists in treating chemistry as an empirical science and laying the greatest stress on the facts without any necessary connection with any particular theory. Dr. Schorger is sound enough on theory, but he uses theory to elucidate facts and not facts to prove the theory, *i.e.*, he makes the facts the main things. He gives his facts as phenomena plus conditions of their occurrence, and products as conditional to both, and there he ends. In his preface he apologises for this modestly enough, but how many other authors of to-day would have resisted the temptation of giving the world a new theory or two after co-ordinating so many facts? In the opinion of the reviewer, this is one of *the* few books in this overcrowded field.

BOOKS RECEIVED.

Pratique du Calcul du Béton Armé. By G. Magnel. Ghent: Van Rysselberghe et Rombaut, Place d'Armes 1. Price 35f.

Aluminium and its Alloys.—By M. G. Corson. London: Chapman and Hall, Ltd., 11, Henrietta-street, W.C. 2. Price 36s. net.

Diesel Engines. Third edition. By A. H. Goldingham. London: E. and F. N. Spon, Ltd., 57, Haymarket, S.W. 1. Price 21s. net.

Text-book of Mechanics. By E. H. Wood. London: Chapman and Hall, Ltd., 11, Henrietta-street, W.C. 2. Price 15s. net.

Die Luftvorwärmung im Dampfkesselbetrieb. By Dipl.-Ing. W. Gumz. Leipzig: Otto Spamer, Heinrichstrasse 9. Price 10 marks.

"Mechanical World" Electrical Pocket Book, 1927. London: Emmott and Co., 20, Bedford-street, W.C. 2. Price 1s. 6d. net.

The Elements of Radio Communication. By O. F. Brown. London: The Oxford University Press, Falcon-square, E.C. 1. Price 10s. 6d. net.

A List of English Clubs, 1927. By E. C. Austen-Leigh. London: Spottiswoode, Ballantyne and Co., Ltd., New Street-square, E.C. 4. Price 7s. 6d. net.

Machine Tool Driving and Feed Gear-boxes. By H. C. Town. London: The Association of Engineering and Shipbuilding Draughtsmen, 96, St. George's-square, S.W.1. Price 2s. net.

A Comprehensive Treatise on Inorganic and Theoretical Chemistry. Vol. VII. By J. W. Mellor. London: Longmans, Green and Co., Ltd., 39, Paternoster-row, E.C. 4. Price 63s. net.

Some Considerations in the Design of Spur and Helical Gearing. By H. Walker. London: The Association of Engineering and Shipbuilding Draughtsmen, 96, St. George's-square, S.W. 1. Price 2s. net.

Ein Jahrhundert Deutscher Maschinenbau (Von der mechanischen Werkstätte bis zur deutschen Maschenfabrik, 1819–1919). By Conrad Matschoss. Berlin: Julius Springer, Linkstrasse. 12 mks.

British Waterworks Year Book and Directory, with Statistical Tables, 1926. General editor, G. P. Warner Terry. London: The British Waterworks Association, 173, Rosebery-avenue, E.C. 1. Price 21s. net.

The Relation of Atmospheric Conditions to the Working Capacity and the Accident Rate of Coal Miners. By H. M. Vernon and T. Bedford. London: His Majesty's Stationery Office, Adastral House, Kingsway, W.C. 2. Price 1s. 3d. net.

Letters to the Editor.

(We do not hold ourselves responsible for the opinions of our correspondents.)

THE NEWTON BI-CENTENARY.

SIR,—The notable scientific distinction of 1927 being the fact that it is the bi-centenary year of Newton's death, it would seem desirable to mark it, where possible, by tributes to his memory more real than merely literary and festival celebrations. The preparation of a revised complete edition of his writings is, it seems, not to be looked for, however appropriate and overdue such an undertaking may be; but a return to their direct study and to the recital and employment of methods and results contained in them, that at least is practicable, and would be a generous homage on their part, if writers and teachers would adopt it.

One of his methods with which a start might well be made is Newton's Theory of Resistance—that theory which Cotes characterised as "his noble theory of resistances." Noble it undoubtedly is, yet none the less it has for long years been consistently passed over, if not forgotten, for too few of us read the "Principia" now, though we one and all allow it to be a scientific classic that can never die.

In place of Newton's "noble theory" we have substituted a so-called Fluid Friction Theory, imperfectly defined, little understood, and based on fallacious reasoning.

To compare for a moment the two theories—our fluid friction theory lays it down fundamentally that a fluid devoid of viscosity offers no resistance to uniform motion through it. This theory has now enjoyed a long scientific innings, but it has not yet enabled anyone, to my knowledge, to calculate the resistances of bodies of the simplest form.

Newton, in his theory, lays it down fundamentally that a fluid devoid of viscosity does offer resistance, and that such resistance varies as the density of the fluid and as the square of the velocity of the body moving uniformly through it.

In the "Opticks" (Query 28)—in 1718, and therefore his matured view—he is more precise, and says the resistance of a sphere "which arises from the attrition of the parts of the medium is very nearly as the diameter, or at the most, as the *factum* of the diameter and velocity of the spherical body together. (Thus anticipating what we call Stokes' Law.) And that part of the resistance which arises from the *vis inertiæ* of the matter is as the square of that *factum*. And by this difference the two sorts of resistance may be distinguished from one another in any medium; and these being distinguished, it will be found that almost all the resistance of bodies of a competent magnitude moving in air, water, quick-silver and such like fluids, with a competent velocity, arises from the *vis inertiæ* of the parts of the fluid." And a little later he again says: "The resistance of water arises principally and almost entirely from the *vis inertiæ* of its matter."

The calculation of any resistance by our fluid friction theory being admittedly impossible, would it not be an appropriate tribute to Newton's memory to give his own *peregregia theoria* a place in his bi-centenary year? Resistances can be calculated by Newton's theory to a high degree of accuracy, as was shown by Colonel Duchemin more than eighty years ago.

For another comparison, take the case of water flowing out through a 1in. circular thin-walled orifice. Calculating in the ordinary manner we obtain a figure which we may call 100, while we know that by experiment we shall get a figure about 62·5. We have accordingly to employ a coefficient of 0·625 before our result is of any value at all. Such a method scarcely deserves to be called scientific. The condition is really worse than this, for our coefficient is not even constant, but must be varied as the diameter varies.

On the other hand, by Newton's theory, the discharge for a 1in. orifice can be calculated directly to within the second place of decimals of the experimental amount. Surely we should be consulting our own practical advantage, as well as honouring Newton's memory, by at least finding a place for his theory—a theory which leads at once to a correct result—alongside of one which is useless without what may be called a "fudging" coefficient.

If it be asked why it is assumed that a fluid devoid of viscosity offers no resistance to uniform motion, the answer may be found in the first three lines of Lambs' "Hydrodynamics."

R. DE VILLAMIL.

January 29th.

THE LARGEST PASSENGER LOCOMOTIVE.

SIR,—The Baltimore and Ohio Railway's 4–8–2 type locomotive No. 5500, described by Mr. E. C. Poultney in your issue of December 24th, 1926, was rebuilt from a 2–10–2 type freight locomotive in 1925.

It is not now the largest passenger engine in this country. In addition to the 4–10–2 type locomotives of the Southern Pacific and Union Pacific railways, which are used in passenger service, although the schedules on which they run are equivalent to those usually associated with express goods trains, the Baltimore and Ohio locomotive is exceeded in size and capacity by the ten 4–8–2 engines delivered by the Baldwin Locomotive Works to the Denver and Rio Grande Western Railway during the past summer.

The following table contains comparative dimensions of the locomotives mentioned:—

The Largest American Passenger Locomotives.

Railway	Southern Pacific	Union Pacific	Denver & Rio Gr. Western	Balt. & Ohio
Type	4–10–2	4–10–2	4–8–2	4–8–2
Total weight, lb.	442,000	405,000	419,310	400,000
Adhesive weight, lb.	316,000	288,500	290,530	274,000
Dia. of drivers, in.	63½	63	67	74
Cylinders, in.	(1) 25×28 (2) 25×32	(1) 25×28 (2) 25×30	(3) 25×30	(2) 30×30
Steam pressure, lb.	225	210	210	220
Tractive force, lb.	83,500	78,000	75,000	68,200
Evaporative H.S., sq. ft.	5,676	5,522	5,093*	5,591
Superheating surface, sq. ft.	1,500	1,505	1,495	1,305
Combined H.S., sq. ft.	7,176	7,027	6,588	6,896
Grate area, sq. ft.	89·6	84·0	95·0	89·17

* D. & R.G.W. engine has tubes 19ft. 6in. long, while other three types have tubes of 23ft. or more, accounting for the difference in evaporating heating surface.

WM. T. HOECKER.

Texas, U.S.A., January 7th.

BRAINS IN THE FOUNDRY.

SIR,—We have entered upon a phase in our foundry life which calls for far more detail in our accounts than at one time sufficed. There are many causes which may account for this change. Competition is keener than it used to be, both at home and on foreign markets; great combines of industrial firms are taking place and have come to stay; new ideas are now entering into the foundries and pattern shops. Manufacturers are being forced by such changes to discard their old-time methods of production and are now calling for facts and figures which will be of material benefit to all; effective mass production demands the latest devices, and smooth progress through the various departments. It has been known for workmen to deliberately delay orders. This stupid rivalry between departments should not exist; it is not only doing wrong to your fellow-worker, but to your employer—result, loss of orders. It has come to my notice of late that employers of labour, union delegates and independent investigators have visited the United States, and upon their return have got in the Press and on the platform in order to demonstrate the American methods of production. What we require is the demonstration in the foundry—how to make oil oddsides to stand 80 lb. pressure, followboards, moulding machines adopted for the right class of work, and the use of their latest methods of production. We must fill the ranks with men of brains as well as hands, men that can take their coats off and show you that it can be done is what we require. Even our Army and Navy are now looking for men with new ideas and brains, and showing that something more is required than a good constitution and a well-filled purse. When you come to study the charges for freight on our railways and find they are the highest in the world, and that their train loads average 130 tons to the American train load of 750 tons, it is to be hoped they will copy a leaf out of this book, and use the brains where they are mostly desired.

J. H. JONES.

Liverpool, January 29th.

"UNEMPLOYMENT—THE GATEWAY TO A NEW LIFE."

SIR,—I have been delayed in giving adequate consideration to the very kind review of my book published in your issue of November 26th last. I appreciate to the full the objection you raise, viz., that our working population is now so "urbanised" that it will perhaps not go back to agriculture. It will be remembered that Sir Daniel Hall's presidential address to the Agricultural Section of the British Association last August brought out the same, and I have glanced at the objection on page 87 of my book. I shall be glad if you will permit me a sentence or two on the point.

Is the objection real, and, if real, ought it to be permitted to continue? My suggested "marriage" of industry and agriculture involves—not the old field work and the old country existence—but just big food gardens and ideal villages. Is there real objection thereto? Are we not, even now, a nation of country lovers at heart, if only the country could be made more interesting to live in? We still sing love-songs of the countryside, not of the town; and dream of retirement to a cottage and garden, never to a mere house in a street. Why not build on these sentiments now? For if ever it does come about that we forget or despise, in complete and unteachable finality, the Nature whose children we are, then indeed there will be no more hope. For, little as we may like it, the issue of all industry is not more than food, home, and a peaceful and healthy life; and all professions and callings, however apparently exalted, come back to that common denominator.

GEO. W. MULLINS.

Birmingham, January 26th.

PARIS-ORLEANS RAILWAY, STEAM-BOILER WAGON

Temperature Conditions in Refrigerated Holds.

A RECENTLY published report issued by the Food Investigation Board of the Department of Scientific and Industrial Research and published by H.M. Stationery Office, deals with the question of temperature conditions in the refrigerated holds of ships carrying apples. Observations have been made in three vessels equipped with three representative systems of refrigeration carrying apples overseas from Australia. It was found that ten to twenty days of the voyage were occupied in cooling down the warm fruit to the temperature of carriage. Little uniformity in temperature was shown during this period, and in the lower holds differences of 10 deg. and 15 deg. between the warmest and cooled parts of the hold were frequent. There was little difference in results—either as regards time of cooling down or temperature equality—between the circulation and the simple grid systems of refrigeration. In cases in which draughts of cold air were employed in a horizontal direction the air was shown to descend and pass mainly through the lower parts of the cargo, missing the upper central portions. In holds cooled by grids it was shown to be desirable to employ hatch grids and roof sections and to provide vertical air channels in the cargo. The suggestion is put forward that with air circulation systems more attention should be paid to the refrigeration of the top of the hold. Even if such improvements be adopted, the opinion is advanced that the task to be undertaken in cooling down a large cargo of warm fruit is a difficult one, and that even under the best conditions rapid refrigeration is not always possible. It seems not improbable that, in order to obtain the best results, it may be necessary to chill the fruit before shipment, thus bringing this particular commodity into line with the procedure adopted with other commodities before they are shipped under refrigeration. Experiments with models, carried out at the National Physical Laboratory during the last year or so, show the great difficulties which have to be encountered in maintaining a uniform temperature in a hold packed with boxes of fruit, and as yet no solution practicable on board ship has been found. The report above referred to was prepared by Mr. A. J. M. Smith, of the Low Temperature Research Station, Cambridge, who was assisted by Mr. J. Poole, of the National Physical Laboratory.

Steam-Boiler Wagon for Heating Electric Trains.

THE problem of how best to heat electrically-propelled trains in France is complicated by the facts that, at present, a comparatively small proportion of the lines is electrified, and that consequently long distance trains have, perforce, to travel over sections of their own and other systems where steam locomotives are still employed. To equip all trains with dual heating systems, so that either steam or electricity might be used as the heating medium, would be an expensive business.

After carefully considering the matter the Paris-Orleans Railway Company decided that the best plan would be to abandon altogether the use of electricity for heating purposes—whether applied direct or employed in a boiler—and to equip its electric rolling stock for steam heating, in the same way as for steam-hauled trains. Such coaches could, of course, circulate on any steam-operated lines, and for the electrified sections it was determined to employ a travelling wagon which might be used partly as a luggage van and partly to contain an oil-fired steam generator. The vehicle evolved is shown above. The two end compartments are used for baggage, the centre part being devoted to the boiler and its accessories.

It was not at all an easy matter to design a steam generator which would meet all the requirements and yet be contained in the space that could be allotted to it. In the first place it was calculated that the amount of steam required to heat an average train was, for ordinary cold weather, from 1000 kilos. to 1500 kilos.—say, from 2200 lb. to 3300 lb.—per hour, while, on occasion, it might amount to as much as 1800 kilos., or nearly 4000 lb. Then, external temperature being a variable quantity which may alter considerably in the course of a single journey, say, from the north to the south of France, the boiler used must be elastic in its capabilities. Another point was that it was necessary that the heating gases should not be discharged into the atmosphere at a higher temperature than, say, 350 deg. Cent. for fear of damaging the overhead electric conductors.

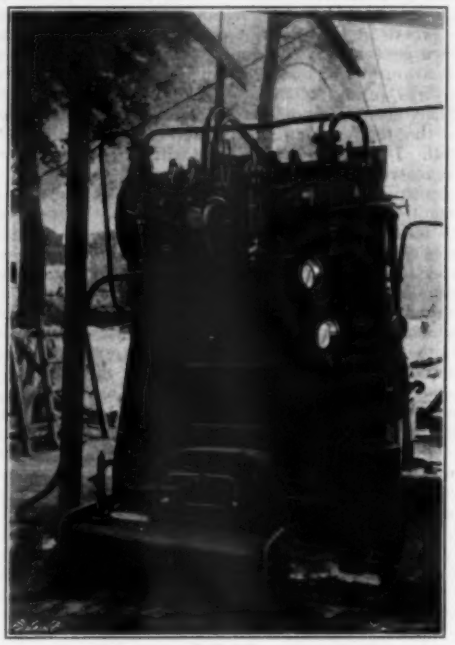


FIG. 2—BOILER UNDER TEST

Some of the boiler makers who were approached declined to undertake to make a boiler which would fulfil the conditions, but les Etablissements J. and A. Niclausse, of Paris, agreed to make the experiment, and we gather that they have been quite successful. The type of boiler chosen is shown in Fig. 1, while two views of it as erected for test at the makers' works are given in Figs. 2 and 3. It was designed to operate at a pressure of 12 kilos. per square c.m., say, 170 lb. per square inch, and was given 35 square metres—say, 377 square feet—of heating surface, and an integral economiser having 15 square metres of heating surface. In addition to heating the trains—for which up to 1800 kilos. per hour were allowed—it was necessary that the boiler should be able to produce enough steam for such purposes as working the air pumps and whistle, for heating the fuel, &c., and it was calculated that it would be necessary that the boiler should have an evaporative capacity of 2100 kilos. per hour, which, with 35 square metres of heating surface, represents an evaporation of 60 kilos. per square metre, or nearly 12·3 lb. per square foot per hour. Then, in order to reduce the temperature

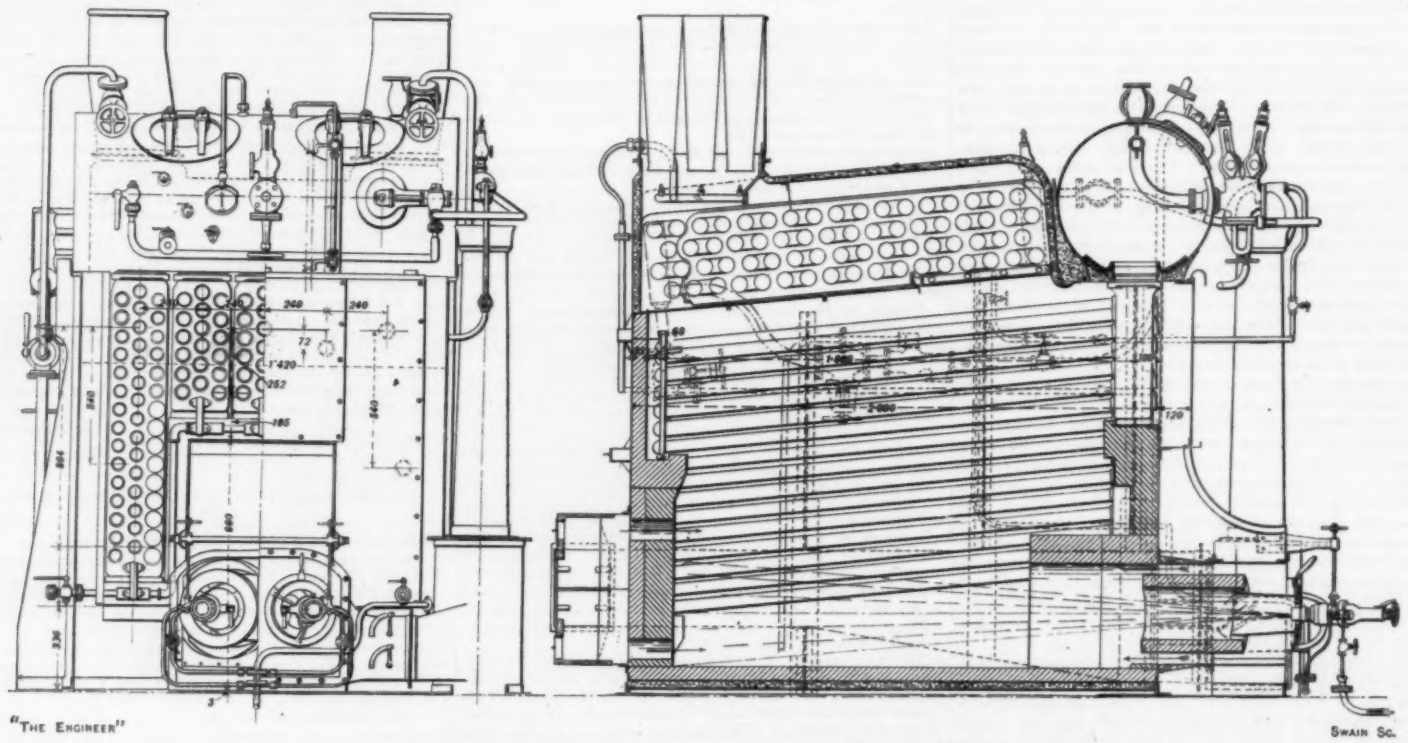


FIG. 1—NICLAUSSE BOILER FOR HEATING ELECTRIC RAILWAY TRAINS

of the gases of combustion, they were passed through a tubular feed-water heater before they were discharged. The overall dimensions of the boiler actually constructed on these lines were 1·42 m. wide, 2·1 m. long, and 2·2 m. high. Its weight in working order, including its charge of water, is about 3800 kilos., or nearly 3¾ tons.

The metal casing which encloses the boiler and feed-water heater is furnished with brackets, by which it may be secured to the underframe of the van, and the boiler is a self-contained unit which can be lifted out of the van through a hole in the roof of the latter for inspection or repairs, or in order, when it is not required for heating, to provide more room for baggage. There are two chimneys which discharge at the roof level, and are arranged one at each side of the longitudinal centre line of the vehicle so as to keep them as far away from the overhead wires

FIG. 3—BOILER UNDER TEST

as possible. The general design of the boiler and of the firing arrangements is so evident from the drawing that no special description is necessary. It may be explained, however, that a steam jet is employed to project the fuel into the boiler, and that the fuel used is mazout.

So far two vans of this type have been delivered and tried in service coupled to electric trains, and their working observed when running normally, when operating under overload conditions and when stopping at stations. The test evaporation figure was, we are informed, 3100 kilos. per hour, and the makers are confident that, given the necessary combustion, 4000 kilos. of steam could be produced in actual service by the boiler without tube troubles or priming. In fact, the boiler has, we are informed, been made to evaporate as much as 18,000 kilos. per hour, the exit gases then having a temperature of 250 deg. Cent., and to give an evaporation of 13·2 kilos. of water per kilogramme of mazout.

The "Osiso" and Its Modifications for Use as a Phonoscope.

WE have received from the Westinghouse Electric and Manufacturing Company of America some particulars regarding what it has named the "Osiso," which is a single-element oscilloscope that may be used as an oscillograph. This instrument is described as being light and portable and to be operable with dry cells. For electrical engineering work it can be used to show alternating-current wave forms and phase relation, and by adding a synchronously driven film holder it may be used to photograph six different alternating-current wave forms and phase relation. The particular development of the instrument with which we are concerned at the moment is that it may be used as a "phonoscope" to enable totally deaf persons to understand speech by viewing the audio-frequency waves of the output of any good radio receiving set or telephone.

In the following we give the exact wording of the particulars as we have received them. They were, we may add, prepared by Mr. J. W. Legg :—

"A spot of light, reflected from the tiny mirror of the galvanometer, moves back and forth on the ground glass of the "Osiso" so as to follow the instantaneous changes in the current. A rotating polygon of mirrors gives a time component to this moving spot of light so that an observer may see waves of light.

"Each sound has a different wave shape. A pure note appears as an endless repetition of a 'sine' wave. The height of the wave is a function of the loudness of the sound. The length of the wave, from crest to crest, is inversely proportional to the frequency. Thus, with each sweep of each mirror, the numbers of oscillations that appear stretched out in a record of light are proportional to the frequency of the note. When a high note is being viewed many oscillations are apparent with each sweep of each mirror. When a low note is being viewed, but few oscillations appear for each sweep of each mirror. Each vowel sound has certain characteristics of wave shape. The waves change with pitch and with different voices, but certain similar characteristics remain for each vowel sound. The vowel 'e,' for example, has a combination of low and relatively high frequencies. It is these high frequencies which cannot be reproduced on a phonograph nor on a poor telephone system. Any ordinary telephone microphone may be connected in series with one or more dry cells and the vibrator ribbon of the 'Osiso.' One may speak into the microphone and see the voice waves dance in the rotating mirrors. A single step-down audio-frequency transformer is used between any radio receiving set and the 'Osiso' vibrator ribbon. Any signal that will operate a loud speaker will give sufficient deflection on the 'Osiso.' If the primary of the step-down transformer is connected in series with the loud speaker coil, then one may hear and see the audio-frequency at the same time.

"No photographic action is required to receive the audio-frequency waves. A deaf person may be taught to understand speech through sight in a class similar to that carried on to teach them to understand speech by feeling the vibrations of a telephone receiver. Such instruction would take much time, but it seems probable that the sight method would be fully successful, and probably much more so, than the method of reception by feeling.

"The polygon of mirrors may be modified so as to give more glimpses of the voice waves, by inclining each mirror at a different angle to the axis of rotation. Thus with four mirrors four waves would appear side by side and the unit might be driven four times as fast without causing overlapping of waves, due to persistency of vision. It should not be necessary for the eye to be focussed on each of the waves. With sufficient experience the observer should be able to get each characteristic even though the eye is focussed to one side of the field of the waves. This is especially possible considering the black background and the waves of light. This multiple wave scheme may be necessary to get consonant characteristics. Vowel characteristics can be picked up with the standard polygon of mirrors with very little training.

"The human ear cannot catch impressions of sounds which are not repeated. Many cycles of a pure note must be picked up by the human ear in order to give the impression of that note. With sight this is not required. The glimpse of one or two cycles of a pure note is all that is required for the eye to grasp the complete characteristic. One cannot say the vowel 'e' without repeating the characteristic's wave cycle dozen of times. A high-speed osisogram 10in. long would show but a fraction of a quickly spoken vowel, yet that small fraction would contain the characteristic wave form repeated many times.

"From this two things are apparent: first, that it would take a film approximately 15ft. in length to photograph a medium length word, if every vibration of the voice was to be recorded; second, the eye does not require all this detail repetition, and hence a film 15in. long with intermittent exposures 1in. long would fully cover the characteristics of the word.

"This intermittent high-speed record could be obtained with a differential shutter arrangement in which the cylindrical shutter rotates about the film drum at a slightly different speed, giving a short exposure on the film every revolution of the shutter and every revolution and a fraction of the film. Now, in addition, if the film drum rotates in a helix, many convolutions of exposure, including a very large number of individual exposures, may be obtained on the one film. When this film is flattened out it will be a page of true 'phonetic' writing, under which writing may be printed the usual characters as in any book. Thus a textbook may be prepared.

"In such a book vowel characteristics would appear first, spoken in a single pitch. The simple change in appearance due to change in volume of sound and hence the amplitude of the waves might then be shown. Then the change in characteristics due to a change in pitch. Then possibly the same vowels spoken by different people. Then might come the study of the still more transient consonants, with their rapid changes in form. Simple words could be taken up and characteristic words to show characteristic syllables. To prepare such a textbook, correctly and fully, would be no mean task. It would be a new art and a very worthy art, for tens of thousands of human beings, who are now greatly handicapped by total deafness, might have a new lease on life on account of this development.

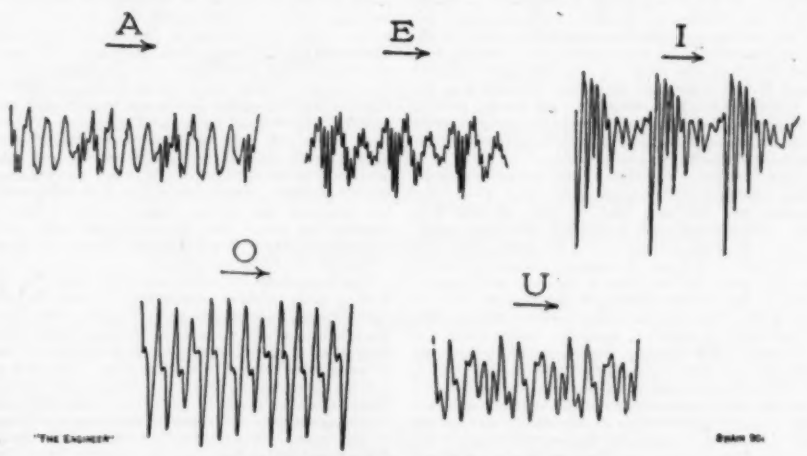
"The conception of using an oscillograph as a phonoscope is not new. The writer thought of that while at school at the Worcester Polytechnic Institute in 1914. However, the bulky oscillographs of that time were very unstable in operation, required approximately 15 ampères, 110 volts of direct current to operate the troublesome arc lamp, gave a rather coarse line wave on the viewing screen, which could be seen by but one person, and required great skill to take satisfactory oscillograms.

"The 'Osiso' lamp will operate on three or four dry cells and give light enough for several persons to see the waves simultaneously in a moderately darkened room. The 'Osiso' does not weigh one-tenth as much as the old arc lamp oscillograph, and costs approximately one-fifth as much. If there is demand enough for quantity production, this instrument may be further simplified and the cost reduced considerably more for phonoscope application.

"It is possible to manufacture a phonoscope having a stationary ground glass with waves appearing on same full size (3in. by 4in., or possibly larger) with light enough to enable a small gathering of possibly a dozen people to view the voice waves. No rotating polygon of mirrors would be used in this instrument. No rocking internal mirror would be used on account of the poor efficiency of this old scheme and the coarse waves resulting. Multiple waves may be made side by side by polarising the galvanometer vibrator with four different values of direct current, or by introducing a mirror (or prism) somewhere between the amp and the cylindrical condensing lens.

"A coat-pocket phonoscope may be made, utilising prismatic binoculars and operating on three pocket-size dry cells. Such an instrument was made several years ago as an oscilloscope, only one ocular being used in this first model. The moving element, to give the time component, is mounted on a tiny disc not much larger than a silver dollar. This may be spun with the finger with little effort if carefully pivoted on jewels. The optical lever is very short and the actual wave very small, but this is magnified ten times or more by the ocular magnifier. No ground glass is used, practically all the light waves reaching the retina of the observer's eye."

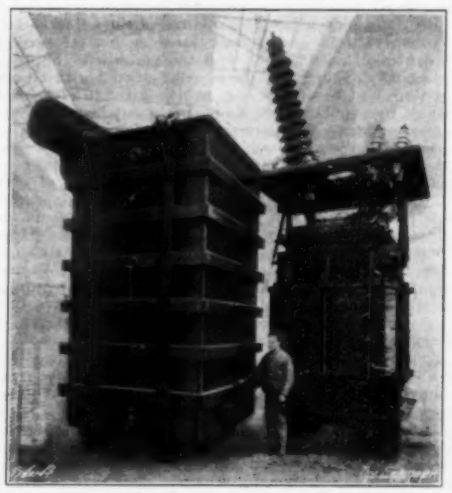
With the description there was also sent an engraving showing the shapes of the waves produced by the five vowel sounds, which we reproduce above.



WAVES PRODUCED BY THE FIVE VOWEL SOUNDS

Large Transformers.

THE ability of British electrical firms to construct transformers of very large capacity and also transformers for voltages much in excess of those used in this country has been proved beyond doubt, and the increasing demand for such units shows clearly that a sound reputation has been established. At the present time some transformers of exceptionally large capacities are being manufactured by the Metropolitan-Vickers Electrical Company under



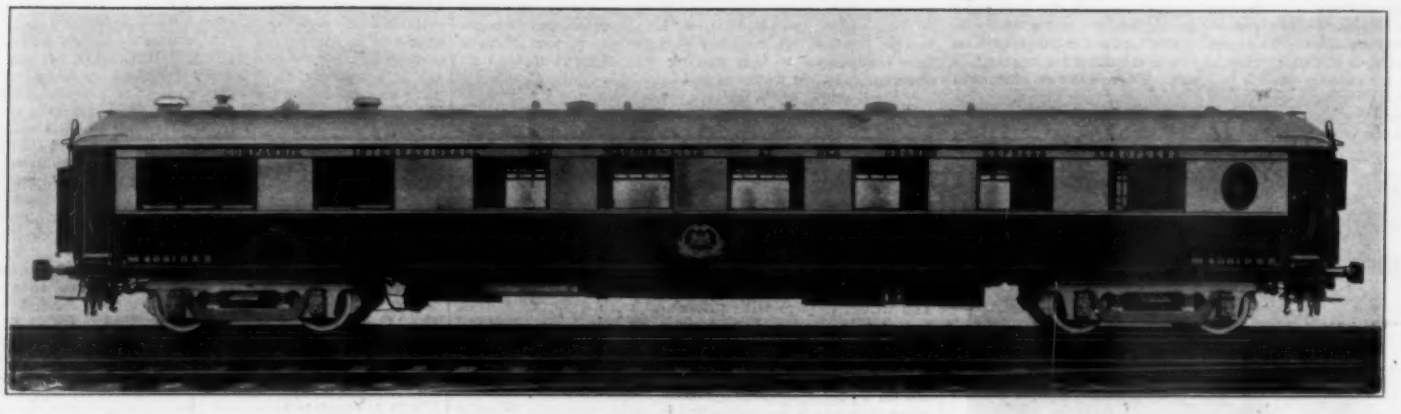
LARGE SINGLE-PHASE TRANSFORMER

contracts recently received. Single and three-phase units now under construction in the company's shops are claimed to be the largest manufactured or installed in this country. With regard to home contracts, the largest single unit transformers produced in Great Britain are being built for the extensions to the Barton power station of the Manchester Corporation, these transformers being three-phase core type units, each of 25,000-kilovolt-ampères capacity, with a pressure ratio of 6600/33,000 volts, and they are to be installed with the 41,000-kilowatt turbo-alternator set recently ordered from the same manufacturers.

The present British record for large-capacity units is held by the Metropolitan-Vickers main step-up transformers in use at Barton, viz., six three-phase 19,500-kilovolt-ampère units, which have been in successful operation for about four years. In design the new transformers will be similar to the original units, which are of the core type and constructed for forced cooling. They

PULLMAN CAR FOR THE CONTINENT

THE LEEDS FORGE COMPANY, LTD., LEEDS, ENGINEERS



will be nearly 16ft. long, 7 feet broad and 17ft. high to the top of the H.T. terminal. Among the transformers ordered for abroad, there are three-phase banks with capacities up to 54,400 kilovolt-ampères per group. Two banks of this capacity and one spare unit are being supplied to South Africa, each bank consisting of three 18,113 kilovolt-ampère single-phase shell transformers, the pressure ratio being 13,650/28,500, and the periodicity 50 cycles per second. The transformers will be fitted with oil conservators and breathers, and will be arranged for forced cooling, two cooling equipments per group being included in the contract. The guaranteed maximum efficiency of these transformers is as high as 99·34 per cent.

A 51,000-kilovolt-ampère bank of transformers of similar construction, but designed for a ratio of 6600/115,000 volts and arranged for outdoor service, is being built for a power station in Europe. The units of this group, as well as those of the 54,400-kilovolt-ampère groups mentioned, will be of greater capacity than any single phase units hitherto manufactured in this country. Some idea of the size of the large-capacity single-phase transformers now being built can be obtained from the accompanying illustration, which shows one of the single-phase units recently manufactured at the Metropolitan-Vickers Electrical Company's works for the Victoria Falls and Transvaal Power Company. The initial power plant, which is being supplied by this firm for the new Waikaremoana hydro-electric power station in New Zealand includes two 20,000-kilovolt-ampère three-phase banks of single-phase transformers and one spare 6666-kilovolt-ampère single-phase unit. These transformers are water cooled and are designed for outdoor service at 11,000/110,000 volts. The Great Indian Peninsula Railway has ordered twelve 3667 single-phase transformers of the self-cooled outdoor type, these being in the form of four 11,000-kilovolt-ampère three-phase banks for 6600/110,000-volt interconnection with the electrification of the main line north-west from Bombay.

Within the last few years Metropolitan-Vickers transformers, aggregating over half a million kilovolt-ampères total capacity, have been ordered and supplied for pressures of 110,000 volts and over, and in order to deal with the increasing demand for larger units and for higher voltages, the company is now completing extensions to its high-tension laboratory, in order to increase its capacity four-fold. The extensions will contain transformers for making commercial tests up to over one million volts.

DURING last month the steamship Colmar tied up at the Great Western Port Talbot Docks and discharged 3000 tons of steel between 9.20 a.m. and two o'clock in the afternoon of the same day.

Pullman Cars for the Continent.

ON Tuesday last, at the invitation of Cammell Laird and Co., Ltd., a party travelled up to Leeds in a special railway coach to inspect several new Pullman cars which have recently been completed by the Leeds Forge Company, Ltd., to the order of Sir Davison Dalziel for the Compagnie Internationale des Wagons Lits et des Grands Express Européens. The order was for thirty cars for the new Nice and Milan service, which started on December 15th last. We understand that the cars are giving every satisfaction. We may remind our readers that the original all-steel sleeping cars for the Wagons Lits service to the Riviera which forms the famous Train Bleu were designed and constructed by the Leeds Forge Company. In many respects they are similar to English Pullman cars, and by special request the interior finish and decoration of the first two cars, known as the Argus cars, are identical with the English Pullman car built by the Midland Railway Carriage and Wagon Company, Ltd., and exhibited at the Wembley Exhibition. The order was for fifteen parlour cars and fifteen kitchen cars, all of which are now practically complete, only a few remaining to be sent to France, *viâ* the Harwich-Zeebrugge ferry service.

The parlour cars have two large open saloon compartments, each seating twelve passengers, and two *coupé* compartments, one at each end of the car, for four passengers. The kitchen cars have also two large saloon compartments, one seating twelve and one eight passengers, whilst at one end of the car is a *coupé* compartment for four passengers and at the other a kitchen and pantry, A good idea of the luxuriousness of the saloons may be gathered from the illustrations which we give above. The whole of the kitchen interior, namely, body, sides and ceiling, is of steel. The carriage door partition behind the stove is also of steel, heavily insulated and provided in its thickness over its entire area with an air space for the flow of a cold stream of air entering from the corridor near the floor. The stove is of the large coal-burning variety and is arranged to heat the water for hot water supply. On the outside the cars are painted blue on the lower panels and cream on the upper, whilst the panels, windows and mouldings are lined with gold; the roof is painted white. The length over buffers is 76ft. 11¼in., the width over outside cornices 9ft. 5½in., and the height from rail to top of roof moulding 13ft. 1½in. The bogie wheel base is 8ft. 2 7/16in. and the diameter of the wheels 3ft. 5½in. The bogie centres are 52ft. 6in. apart. Each parlour car will accommodate thirty-two passengers and each kitchen car twenty-four passengers; their respective weights are approximately 46½ tons and 50½ tons.

The whole of the car structure is of steel, the assembly of the parts in the works being effected by means of special jigs, whereby interchangeability and great acceleration of the speed of manufacture are secured. The body sides are composed of vertical pressed pillars connected together longitudinally by rolled angle sections, the whole being covered by steel sheeting held down firmly by the moulding. The platform and body ends are constructed in a similar manner. The roof comprises transverse steel members pressed to the contour of the roof and connected by longitudinal angles, the whole being covered with steel sheet, the lap joints of which are held down by moulding to prevent any possibility of leakage. The floor is of key-section corrugated steel on which is laid an insulating and fireproof composition. The whole of the body outer sheeting on the inside is covered with insulating material, and provision for the attachment of the interior finish is made by means of the Leeds Forge patented fibre block method, which consists of securing the interior lining, &c., by wood screws to special fibre blocks riveted to the steel work. The underframe is practically the same as that employed for the Train Bleu, but some reduction of weight has been secured by slight modifications. The feature of this design, which, we may mention, is patented by the Leeds Forge Company, is the use of cast steel ends, a main centre longitudinal fish-bellied girder, and through cross bars. The sole bars are made of rolled Z sections connected firmly at the tail pieces on the end castings and arranged so as to form landings for the bottom angles of the body sides. The buffing gear is of the equalising type, the ends of the buffer shanks being fitted with shoes bearing on large laminated springs and connected by equalising bars. Westinghouse brakes are fitted and are actuated by 17in. cylinders.

The bogie frame consists of one steel casting, of which the axle guards, bolster suspension brackets, block hanger brackets, &c., are cast to form integral parts, thus reducing the number of pieces in the finished bogie to a minimum. The wear of pinholes, &c., is provided for by the insertion of hard steel bushes in the castings; the axle guards and bolster wearing surfaces are faced with suitable liners. The bogies as a whole are of the equalising beam type, designed with a view to obtaining the easiest possible riding of the cars. Wheels, axles, and axle-boxes are of the Wagon Lits standard, as required by the railways over which the cars are being operated. Electric lighting is provided by the Stone's system, current being generated by a motor slung from the underframe and belt driven by a pulley on one of the axles. The carriages are warmed by a low-pressure plant manufactured by the Laycock Engineering Company, Ltd.

Luncheon was served on the down train, and on arrival the party went to the works of the Newlay Wheel Company, Ltd., at Newlay, which is now associated with the Leeds Forge Company, Ltd., and Cammell Laird and Co., Ltd. There the visitors were shown the last five of the thirty cars which have been built. They were also given an opportunity of inspecting the method of manufacturing

solid forged and rolled wheels. They then returned to the Armley Works of the Leeds Forge Company, Ltd., which they inspected, and after tea had been served they returned to town in the special coach which Cammell Laird and Co., Ltd., had provided. On the up journey an excellent dinner was provided. We may add that the whole arrangements for the trip were admirably carried out and that every thought was given by Cammell Laird and Co., Ltd., for the comfort and convenience of their visitors.

A Hopper-cooled Oil Engine.

In an article appearing in our issue of December 10th, in which we described some of the engineering exhibits at the recent Smithfield Club Show, brief reference was made to a new type of hopper-cooled oil engine for small powers, which has been put on the market by Crossley Brothers, Ltd., and is built at the firm's Elstow Engineering Works, Bedford. The engine—which is shown in Fig. 1—

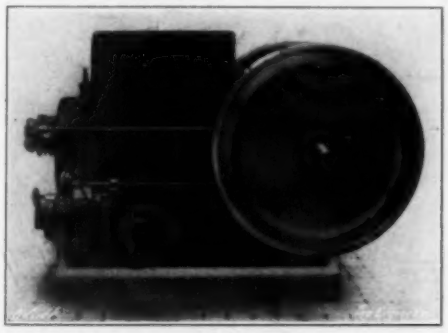


FIG. 1—HOPPER-COOLED OIL ENGINE

is of the four-cycle single-cylinder horizontal type, designed for either petrol or paraffin fuel. Fig. 2 shows a longitudinal section through the bed-plate and cylinder, with the piston in the position which corresponds to a closing exhaust valve. It will be seen that there are two valves in the cylinder head, an upper inlet valve and a lower exhaust valve. Both valves are tappet-operated from a single rocker arm, which is carried on a bearing mounted on the cylinder head. Attached to the end of the rocker arm is a small bell crank, which in turn is connected to the push rod and cam roller. The intermediate cam shaft is gear driven from the crank shaft, and a spur wheel on the same shaft also drives the magneto and the governor. The magneto, which is fitted with an advance and retard lever, is conveniently mounted on the end of the crank case on a stiff bracket, which gives access to the interior of the crank case. Below the magneto bracket is the lubricating oil filling cap, the height of oil required being indicated by a small peg gauge which becomes visible as soon as the filling cap is removed. A centrifugal type governor is fitted at the side of the engine, and it operates, by means of a push rod, a throttle valve in the carburetter system. In order to facilitate starting when the engine is being run on paraffin fuel, a petrol cup and a priming tap are fitted at the top of the cylinder over the combustion space.

The lubricating arrangements are of interest. Instead of depending on splash lubrication for the reciprocating parts, an oil thrower disc is mounted on the crank shaft, which dips into the oil bath and transfers lubricating oil to a distributing trough at the top of the crank case, from which it is fed to the various bearings and reciprocating parts. Although the engine as illustrated herewith is designed for hopper cooling, it is made so that it can readily be converted for tank or radiator working. Crossley Brothers, Ltd., are manufacturing three sizes of engine of the type described, namely, two, three and six horse-power models. The smaller engines are designed for the moderate speed of 700 revolutions per minute, and a still slower speed of 550 revolutions has been adopted for the six horse-power size. The makers claim that the engine is one which should find a wide field of application for agricultural contractor's work, and the many industrial purposes for which such engines are now used.

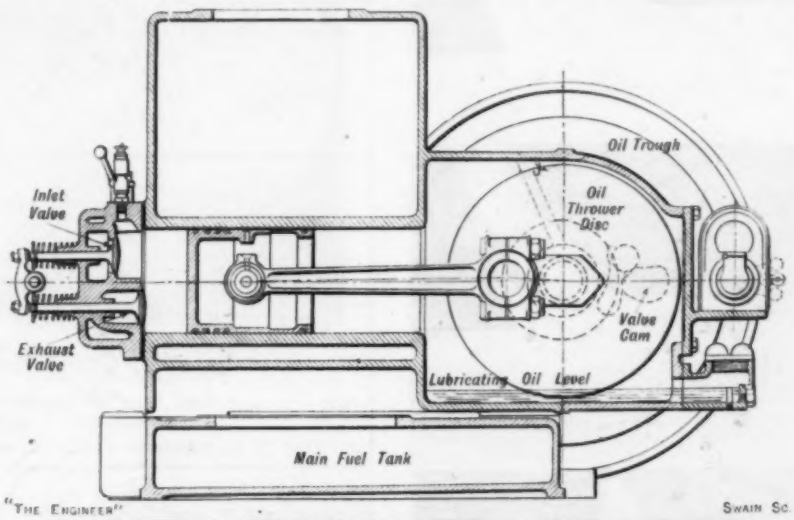


FIG. 2—LONGITUDINAL SECTION THROUGH CYLINDER OF HOPPER-COOLED ENGINE

Applications of Power on Gasworks.*

By HAROLD CHARLES SMITH, Assoc. M. Inst. C.E.

After a brief mention of the uses of pneumatic, hydraulic and gas power, the applications of steam on a gasworks with an output of more than 15 million therms per annum are detailed. In manufacturing this gas, approximately 148,000 tons of coal and 2,700,000 gallons of gas oil are used; 87,000 tons of coke and breeze are obtained as a by-product, of which 18,500 tons of coke are used for the manufacture of water gas and 8600 tons of coke and 26,700 tons of breeze as boiler fuel. The steam generated on an average day is shown to be at the rate of 44,110 lb. per hour from and at 212 deg. Fah., or 16,718 H.P. The cost of generation, exclusive of capital charges, but including fuel, labour, water, repairs and maintenance is shown to be 11·3d. per 1000 lb. of steam, or 25·3d. per ton.

The boilers in which this steam is generated are described, their actual outputs being compared with their rated capacities. Five waste heat boilers are included in the boiler plant. The boiler efficiencies and load factors are stated. The quantity of steam generated is allocated in the following manner to the various pieces of plant and machinery for which it is used:—

	Pounds per hour from and at 212 deg. Fah.
Carburetted water gas	3,458
Steaming vertical retorts	1,581
Generating electricity	4,022
General power purposes	33,105
Boiler grates, ejectors, &c.	1,944
	44,110

From a balance drawn up between the steam generated and the H.P.-hour output obtained by its use, an efficiency of transmission of energy from heat in steam to B.H.P.-hour is shown to be 3·5 per cent. This low efficiency is due to the fact that steam is used in a large variety of scattered units, the majority of which have been in use for several years and are working under non-condensing conditions.

The savings in labour to be effected by linking up the whole of the boiler plant and by converting certain of the hand-fired boilers to mechanical stoking is shown to be £790 per annum on a capital outlay of £1810. This saving is in addition to any saving in fuel, due to the levelling up of the load and to the increase in the proportion of steam made on mechanically operated boilers and waste heat boilers.

The generation and use of electrical power on a gasworks is dealt with. The efficiency of the generation of electricity from heat in steam supplied to engines to heat in electricity generated is shown to be 10·1 per cent., and the efficiency of the generation and transmission of electricity from heat in steam supplied to engines to brake horse-power developed on works motors is shown to be 6·1 per cent., which is comparable with the efficiency of 3·5 per cent. given for the use of steam power.

Of the 16,718 H.P. of steam generated, 2647 H.P. is used for gas making and purposes other than power, and 14,071 H.P. for power purposes. Of the latter, 1524 H.P is converted into electrical energy, giving 147·8 H.P. of electricity.

The author suggests that in designing a new gasworks of a similar size to the one under review, power would be most economically produced and applied as electricity. This could be generated by steam at a central station, the bulk of the steam being produced by waste heat boilers. Instead of steam being used in small units at scattered points, it would then all be used at one point, the exhausts of engines using it discharging into suitable condensing plant.

Assuming that the mean total power required on a new works would be the same as on the existing works, 494·0 B.H.P. would be required on an average day. If this were applied as electricity with an efficiency from steam to motor of 6·1 per cent., it would be necessary to generate only 8098 H.P. of steam instead of 14,071 H.P. as at present. A plant capable of generating 818 H.P., or 610 kilowatts, would be required.

With this plant a higher efficiency should be obtained than on the 150-kilowatt plant now in use, and assuming this to be 14 per cent., the steam required would be only 5843 H.P. The saving in steam would amount to 233 tons per diem, which at 25·3d. per ton gives a saving of £8963 per annum.

If only 5843 H.P. of steam were required instead of 14,071 H.P. as at present, it is shown that it would be possible to make 83 per cent. of the steam required on the works for gas making and power purposes—apart from that necessary for the working up of by-products—on waste heat boilers under average day conditions. Under existing conditions it would only be possible to make 42·1 per cent. of the steam required from the waste heat of the various carbonising processes.

The works produce 3000 million cubic feet of gas per annum, having a calorific value of 500 B.Th.U. per cubic foot. Of this production, 25 per cent. is water gas. To make this gas, 148,000 tons of coal are required. From each ton of coal carbonised 950 lb. of steam from and at 212 deg. Fah. can be raised by waste heat boilers. This equals 385,000 lb. per diem. A quantity of 30 lb. of steam per 1000 cubic feet of carburetted water gas, which equals 61,000 lb. per diem, can also be raised. Therefore the total steam available from waste heat is 446,000 lb. per diem. The requirements under present conditions = 44,100 × 24 = 1,058,640 lb. per diem. Therefore the percentage that can be raised from waste heat = 42·1 per cent.

Assuming that the whole of the power requirements were supplied as electricity generated at an efficiency of 14 per cent., the requirements for power would be 5843 × 24/0·379 = 370,000 lb. of steam per twenty-four hours. In addition, 167,600 lb. are required for gas making and other purposes, making a total of 537,600 lb. Under these conditions, 83·0 per cent. of the total requirements could be met by waste heat.

No comparison is made between the capital costs to be incurred by supplying the power requirements of a new works by means of steam and electricity as at present, or alternatively, by means of steam-generated electricity only.

* Abstract of paper to be brought forward for discussion at the Institution of Civil Engineers on February 8th.

SIXTY YEARS AGO.

We have in previous notes made occasional reference to the disgraceful state of the river Thames in the 'sixties of last century, but for a complete and very striking picture of the condition of that great waterway and all the factors attending transport upon it, we must turn to a leading article in our issue of February 1st, 1867. The river in its then state, we wrote, would be a reproach to a colonial port. Its custodians had poured into it every abomination they could collect or create until its emphatic warnings made the process no longer possible. Romance, even the poor romance of villainy, had been driven from its waters. Its venerable mud banks exacted a toll upon the poor crowded in their houses near them. At last the river started to poison our legislators, and only then did they begin to take notice of its state. But in spite of the hasty efforts made to correct matters, a million people above London continued to pour pollution into the waters of the river. It was not, however, only with the sanitary condition of the Thames that fault could be found. Along its banks no effort had been made to secure harmony in the buildings that had been allowed to spring up. Palaces and timber yards, fine old Gothic buildings and gasometers, well-tended gardens and shabby warehouses, set at all angles and shore lines, fringed with wide mud banks, a mass of anchored barges or a raft of timber, presented a jarring picture and destroyed all general effect. Of the bridges which crossed the river two alone, London Bridge and Westminster Bridge, served a useful purpose. Waterloo and Southwark Bridges had been rendered all but useless by the continued demand for tolls from all those using them. On the surface of the river the steamboats plying for public custom had been running, the youngest of them, for at least twenty years. They had just enough power to struggle through the bridges against the tide and not enough to enable them to avoid dangerous collisions with the tidal barges and lighters which, clumsy and unmanageable, still provided the only above-bridge means of carrying merchandise on the river. The steamboats were dirty, their cabins were stifling dens with headroom only for a child, and the descent of their cabin stairs invited a broken neck. Their masters' orders to the engine-rooms were still transmitted verbally by "call-boys." These pieces of "antediluvian lumber" were, however, outdone by the Thames landing stages. For the most part these stages were superannuated barges, which were only kept afloat by frequent pumping. They were approached by flights of steps or inclines, the floors of which, through decay, threatened the traveller with a visit to some indefinite region below. In one instance a series of barges forming a stage provided such a confusion of pay-boxes for the different steamers—the Iron-boat, the Express, the Green boat, an antiquity that took one to Greenwich and so forth—that even the piermen themselves were confused and bewildered in their directions to would-be passengers. Such a set of crazy, ramshackle, rotten, disgraceful steamboat piers as existed between Battersea Park and Deptford would not, we wrote, be tolerated by any civilised people except cockneys. To-day we have little cause for pride in the appearance of the Thames as it flows through London, but thanks to our improved drainage system it is no longer a source of pestilence.

Vacancies for Aircraft Apprentices.—The Air Ministry announces that five hundred aircraft apprentices, between the ages of fifteen and seventeen, are required by the Royal Air Force for entry into the schools of technical training at Halton, Bucks., and at Flowerdown, near Winchester. They will be enlisted as the result of an open competition and of a limited competition held by the Civil Service Commissioners and the Air Ministry respectively. Successful candidates will be required to complete a period of 12 (twelve) years' regular Air Force service from the age of eighteen, in addition to the trading period. At the age of thirty they may return to civil life or may be permitted to re-engage to complete time for pension. Full information regarding the aircraft apprentice scheme, which offers a good opportunity to well-educated boys of obtaining a three years' apprentice course of a high standard and of following an interesting technical career, can be obtained on application to the Royal Air Force, Gwydyr House, Whitehall, London, S.W. 1.

Work-hardening Properties of Metals.*

By EDWARD G. HERBERT.

The Hardness Induced by Cutting Tools.

In order to investigate the hardness induced by the tool in the process of cutting metal, a uniform procedure was adopted. A bar of the metal under investigation was chucked in the lathe and a cut ¼in. deep was taken with a straight-edged side tool, the feed being $^1/_{32}$in. and the speed 65ft. per minute. The lathe was quickly stopped while the cut was in progress and the tool withdrawn, leaving a chip attached to the bar. A section was cut parallel to the axis of the bar through the chip and the adjacent metal, and the section was mounted in fusible metal, polished, etched, and tested for hardness at a number of points around the zone of separation. The test used was the time test, made with the Herbert pendulum hardness tester. For the convenience of those not familiar with the pendulum time hardness numbers, conversion of these has been made into approximate Brinell numbers, which are placed in brackets after the time numbers. The conversion was effected by the following formulas :—

For brass, $B = 0{\cdot}29\ T^2$.
For soft steels, $B = 0{\cdot}36\ T^2$.
For steels harder than 280 Brinell, $B = 10\ T$, or $B = 13{\cdot}5\ d\ T$, where B is the Brinell hardness number, T the time hardness number using the 4 kilo. pendulum and 1 mm. steel ball, and $d\ T$ the time hardness number with 4 kilo. pendulum and 1 mm. diamond. The diamond, owing to its greater hardness and rigidity, gives lower readings than the steel ball, hence the different conversion factors.

The metals selected for experiment were :—

A, a mild steel of 35 tons per square inch tensile strength time hardness 21·4 (163 *B*).
B, stainless iron (0·1 C, 13·5 Cr) ; time hardness 19·7 (140*B*).
C, stainless steel (0·1 C, 17·2 Cr, 7·9 Ni) ; time hardness 19·9 (142*B*).
D, stainless steel (0·26 C, 13·2 Cr) ; time hardness 27·2 (265*B*).
E, stainless steel (0·11 C, 15·7 Cr, 10·5 Ni) ; time hardness 18·0 (116*B*).
F, rod brass ; time hardness 19·2 (106*B*).
G, cast iron ; time hardness 29·3.

Photomicrographs of the sections are given in Figs. 1 to 6, and accompanying each photograph is a chart giving the pendulum time hardness of each spot tested. The brass chips in Fig. 6 appear separate, but were actually attached at one end to the bar. It was not possible to obtain an attached chip of cast iron, but a chip was sectioned and tested for hardness, the microstructure of the chip and of the bar being shown in Figs. 7 and 8.

From these figures it appears :—

(*a*) That in the brittle metal, cast iron, the tool caused no distortion of the metal and no work hardening.

(*b*) That in brass there was a slight distortion of the structure and a small amount of work hardening. The manner in which the brass chip is detached by shear with slight distortion of structure is shown in Fig. 9.

(*c*) That in the steels the distortion of the structure was very severe, and the hardening of the metal in all cases considerable, but very different in degree. The work hardness figures are discussed below, but attention is here drawn to the hardness of the metal immediately ahead of the tool where separation of the chip was about to take place. It is evident that in every case except that of cast iron the tool was actually cutting metal whose hardness was very different from that of the original bar. This is shown in Table I., in which the metals are placed in the order of their original time hardness. The hardness in the path of the tool and the percentage increase of time hardness at this point are given.

Table I.—*Metals Arranged in Order of Original Time Hardness.*

Specimen.	Original hardness.	Hardness in path of the tool.	Time hardness increase, per cent.
Stainless steel E ..	18·0 (116*B*)	37·8 (378*B*)	110
Brass F	19·2 (106*B*)	24·1 (169*B*)	12·5
Stainless iron B ..	19·7 (140*B*)	31·45 (315*B*)	60
Stainless steel C ..	19·9 (142*B*)	43 (430*B*)	115
Mild steel A	21·4 (163*B*)	30 (300*B*)	40
Stainless steel D ..	27·2 (265*B*)	36 (360*B*)	32
Cast iron G	29·3	29·3	0

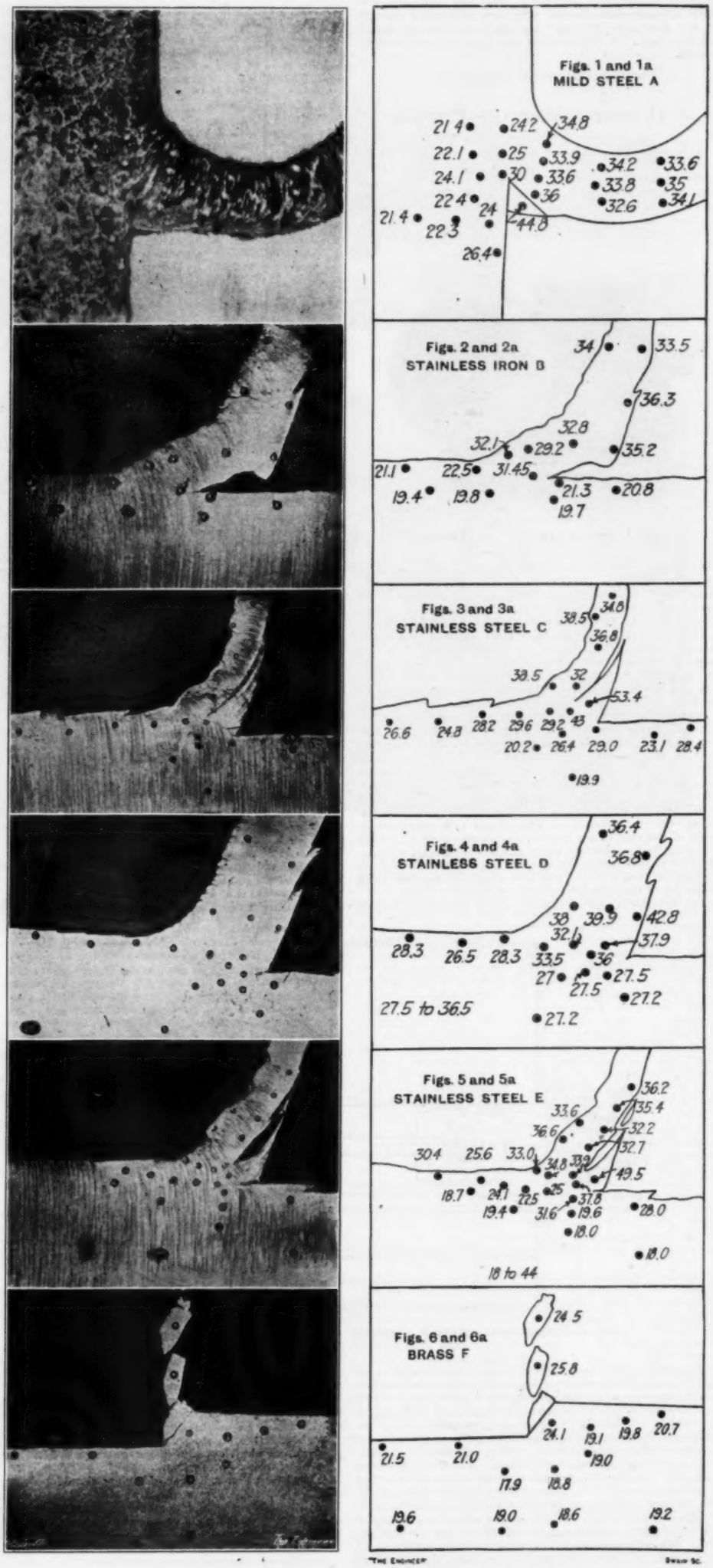
Five of the specimens were originally quite soft, and the specimen which had the lowest original hardness, stainless steel E (*T*18, 116*B*), was hardened by the tool to *T*37·8 (378*B*), being exceeded in this respect only by stainless steel C, whose hardness was increased by the tool from *T*19·9 to *T*43 (430*B*). The steel which had the highest original hardness, stainless steel D, was only slightly hardened from 27·2 to 36. The mild steel A was originally harder than stainless iron B, but under the action of the tool the order of hardness was reversed, while the hardest of all the specimens, cast iron G, was not hardened by the tool.

As to the general disposition of hardness, it is seen in Figs. 1*a* to 6*a* that there exists in front of the tool a hardness gradient rising from the undistorted body of the bar towards the point of separation of the chip, and that this gradient is continued past the point of separation into the chip, where the greatest hardness is generally found. (The hardness of the "built-up edge" is discussed later). Cutting takes place at a point on this hardness gradient which is always higher than the original hardness of the metal, but the hardness where cutting takes place differs from the original hardness according to the characteristics of the metal in respect of (*a*) its ductility or brittleness, and (*b*) its capacity for work hardening.

In attempting to estimate the resistance which a given metal will offer to a cutting tool it seems obvious that if we

* Paper presented at the annual meeting of the American Society of Mechanical Engineers, New York, December 6th to 9th, 1926.

THE HARDNESS OF METAL CHIPS



FIGS. 1 TO 6 & 1A TO 6A—CHIPS IN VARIOUS METALS AND THE HARDNESS INDUCED IN THEM BY THE CUTTING TOOL

except metals such as cast iron and brass, which are broken into fragments rather than cut, the predominating factor must be the hardness of the metal which the tool is actually cutting, since this determines the force which the tool must exert in order to crush and finally rupture the metal. Likewise estimating the machinability of a ductile metal by its destructive action on the tool, three principal factors come into play, the force exerted on the tool face tending to cause wear, which depends on the hardness in the path of the tool; the heat generated, which depends on the hardness in the path of the tool, and the ratio between the hardness of the tool and the hardness of the metal in contact with it. Thus the resistance to cutting and the blunting of the tool are governed by the hardness induced by the tool. The original hardness is of little account, since this hardness no longer exists where cutting takes place.

Maximum Induced Hardness.

It has been shown above that the cutting tool hardens a ductile metal and that the actual separation of the chip takes place in a zone that has been so hardened. The capacity for being work-hardened differs greatly in different metals, and it is convenient to have a means of measuring work-hardening capacity without resorting to a cutting test and the laborious method of sectioning and testing for hardness.

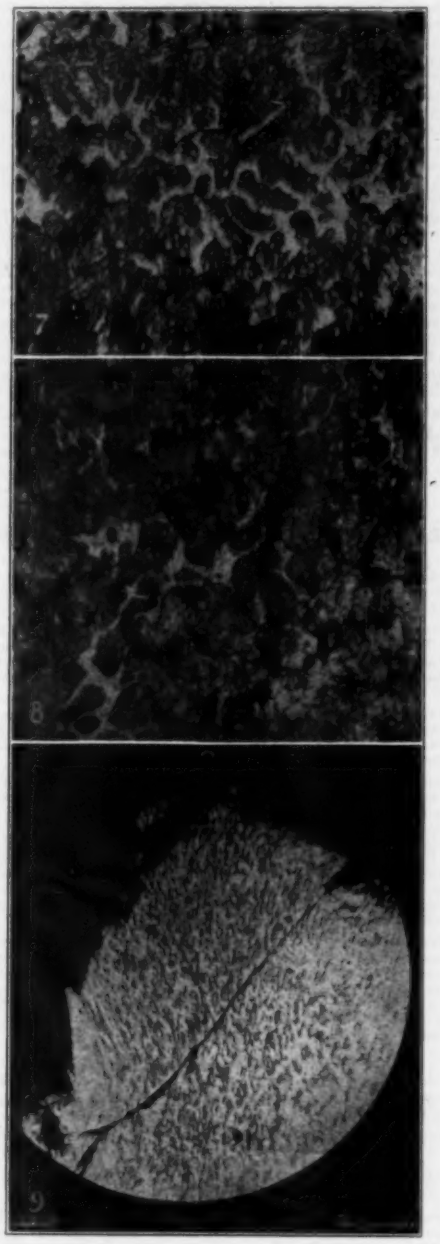


FIG. 7—UNDISTORTED STRUCTURE OF CAST IRON CHIP. TIME HARDNESS 29·5

FIG. 8—STRUCTURE OF CAST IRON BAR G. TIME HARDNESS 29·3

FIG. 9—SLIGHT DISTORTION OF STRUCTURE IN BRASS CHIP

The measurement of the hardness capable of being induced by cold work is effected by a recently developed method of using the pendulum hardness tester. This instrument consists of an arched weight of 4 kilos. supported on a ball 1 mm. in diameter, the centre of gravity of the pendulum being 0·1 mm. below the centre of the ball. An illustration of the pendulum appears later. When the pendulum is placed gently on a specimen the ball makes an impression exactly like a Brinell impression—see Figs. 1 to 6—and when the pendulum is caused to oscillate through a small angle the ball rolls in this impression without slip and the time period of oscillation measures the hardness of the specimen. The time hardness number is the number of seconds occupied by ten single swings, a hard specimen and a small impression being indicated by a slow rate of oscillation and a high time hardness number.

In order to measure the capacity of the specimen for being hardened by cold work, the pendulum is tilted while still resting in the original impression, first to the right, then to the left, then back to its original vertical position. The effect of these motions is to elongate the impression into the form shown in Fig. 10, to roll the metal by two passes of the ball, and to harden it. The pendulum is now caused to oscillate as before through a small angle while resting in the centre of this rolled and hardened surface, and a second time test is made which gives the induced hardness due to two passes of the ball. The effect of this second time test is clearly seen in the bright band in the centre of the impression Fig. 10. Just as the size of the original circular impression was measured by the time of swing of the pendulum, so the induced hardness of the rolled surface is measured by the width of this band and by the number of seconds for ten single swings of the pendulum while resting on it. If the metal has a very high work-hardening capacity, the central band is indistinguishable, just as the impression made by the time test on very hard steel is invisible. Fig. 11 shows the effect of two passes in manganese steel, the original hardness being 21 (158*B*) and the hardness induced by twice rolling 45·5 (455*B*). The induced hardness due to two passes of the ball having been measured, the rolling process is repeated by tilting the pendulum again to the right, to the left, and back to the central position; a third time test is now made and this gives the induced hardness due to four passes of the ball. The process is repeated for six, eight, ten or more passes if necessary, but it is invariably found that after a certain number of passes, usually six to ten, the hardness reaches a maximum and then declines. Once the maximum has been passed no further increase of hardness can be induced by further rolling. The "maximum induced hardness" is then a measure of the capacity of the metal to be hardened by cold work.

Table II. gives the actual readings in "time work-hardening tests" made on the various metals used in the cutting tests described in the first section of this paper, and on certain other typical metals.

It will be noticed that metals differ greatly not only in respect of the maximum hardness they are capable of attaining, but also in the rapidity with which they attain it. Thus the stainless iron B, hard carbon steel, and brass attained their maximum hardness after two passes of the ball, whereas copper required eighteen and stainless steel C twenty passes to harden them fully.

In Table III. the steel specimens used in the cutting tests referred to in the first section are placed in the order of their maximum induced hardness measured with the pendulum. The hardness induced by the first two passes of the ball is also given, from Table II., and the hardness in the path of the tool and the maximum hardness of the chip from Figs. 1*a* to 6*a*.

It is seen that the hardness in the path of the tool is always less than the maximum hardness induced by the pendulum work-hardening test, but approximates to the hardness induced by the first two passes of that test. The order of hardness induced by the pendulum and by the tool is precisely the same, and is totally different from the order of original hardness.

The chip hardness is variable and presents some anomalies; for example, the mild steel chip was abnormally hard. In this and two other cases the hardness of the chip was greater than the maximum hardness that could be induced by rolling with the pendulum, while in the cases of stainless steels E and C the chip was less hard than the metal immediately in front of the tool. Some of these anomalies, especially the last, may be due to the effect of heat. Cutting was done dry, and the chip attained a temperature which was in all cases high, and perhaps sufficient to cause annealing. Since the wear and eventual failure of the tool is normally caused by abrasion of the chip, it would appear that the ratio between tool hardness and chip hardness must be a principal determining factor in tool durability. It is not possible to determine the effective hardness of a chip which may have been raised to annealing temperature, but for the purpose of estimating the hardness which the tool must possess in order to resist the abrasion of a chip, it may be safe to assume that the hardness of the latter is not less than the maximum induced hardness measured by the pendulum work-hardening test.

Referring to Table II. it is seen that brass F and cast iron G both possessed a considerable capacity for work hardening. This can have had little adverse effect on their machinability, since they were not hardened by the tool, but under some cutting conditions the work-hardening capacity of such metals exercises a decisive influence, as all will be aware who have tried to file brass with a blunt file or to cut cast iron with a hacksaw which has lost its sharpness. A blunt tool may harden brass, cast iron, and some bronzes to such an extent that they are almost impossible to cut.

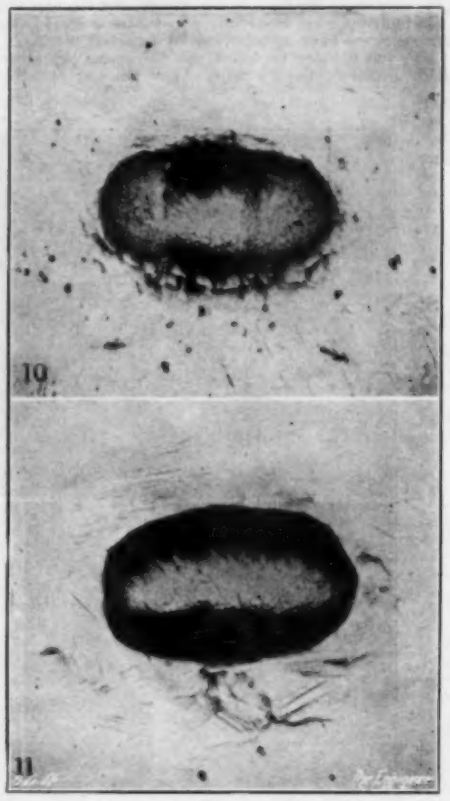


FIG. 10—TIME-WORK-HARDENING TEST IMPRESSION IN MILD STEEL. ORIGINAL HARDNESS, 22; MAXIMUM INDUCED HARDNESS, 29

FIG. 11—TIME-WORK-HARDENING TEST IMPRESSION IN MANGANESE STEEL. ORIGINAL HARDNESS, 21; INDUCED HARDNESS (TWO PASSES), 45·5

Table II.—*Time Work-hardening Tests.*

Passes of ball.	0	2	4	6	8	10	12	14	16	18	20	
Mild steel A	*21·2*	30·4	30·4	30·7	*31·5*	30·4						
Stainless iron B	*19·6*	*32·5*	31·6	30·4								
Stainless steel C	*19·7*	41·2	45·4	47·3	48·2	49·8	50·3	51·5	52·3	52·7	*52·9*	49·6
Stainless steel D	*27·5*	35·6	35·8	36·3	*36·5*	36·2						
Stainless steel E	*18·0*	38·2	41·9	43·1	*44·0*	43·8						
Rod brass F	*19·4*	*32·0*	32·0	31·8								
Cast iron G	*30·0*	36·4	37·5	38·2	40·6	*40·8*	40·2					
Manganese steel	*21·0*	45·5	52·4	54·0	56·2	*57·2*	44·6					
Hard carbon steel	*71·0*	*89·0*	88·0	86·0								
Aluminium bronze	*22·4*	36·0	40·3	40·6	41·8	*42·3*	40·4					
Aluminium[1]	*5·5*	9·8	10·1	10·3	*10·7*	10·6						
Copper, cast[1]	*6·8*	17·5	19·8	20·8	21·5	23·5	23·5	23·5	23·7	*24·4*	24·4	24·2
Tungsten	*37·9*	56·6	57·9	*58·8*	58·5							

[1] Aluminium and copper were tested with a 3 mm. etched steel ball to prevent slip.

Table III.—*Time Hardness.*

	Induced by pendulum.		Induced by tool.		Original.
	Maximum.	Two passes.	Path of tool.	Chip.	
Mild steel A	31·5	30·4	30·0	36·0	21·4
Stainless iron B	32·5	32·5	32·45	34	19·7
Stainless steel D	36·5	35·6	36·0	39·9	27·2
Stainless steel E	44·0	38·2	37·8	36·6	18·0
Stainless steel C	52·9	41·2	43·0	38·5	19·9

Chip Formation. The Built-up Edge.

In order to make clear what follows it is necessary to refer to the structure known as the "built-up edge" on cutting tools. This has often been supposed to consist of particles of metal scraped from the bar by the sharp edge of the tool and accumulating on the top surface of the tool between the actual edge and the point where the chip impinges. The accompanying photographs—Figs. 12 to 17—show the successive stages of its formation and should suffice to dispose of the popular conception.

Fig. 12 is a chip of stainless iron a few seconds after cutting commenced. A large fissure runs ahead of the tool and the surface of the chip where it impinges on the tool is dragged back by friction and consolidated into a hard layer whose structure is continuous with that of the chip, except at the upper part where separation has commenced. This confirms the statements of Rosenhain and Sturney, whose experiments were conducted on chips in early stages of formation and who remarked on the continuity of structure of the "deformed area" and the chip.

A somewhat later stage is shown in Fig. 13, where the first layer has been almost worn away and has been overlaid by five successive layers, the last of which is partly continuous with the chip, the separated portion having been broken in withdrawing the tool.

The successive layers are even more clearly shown in Fig. 14, where the edge is beginning to assume its characteristic triangular form and is seen to be collecting material not only from the chip, but from the lower surface.

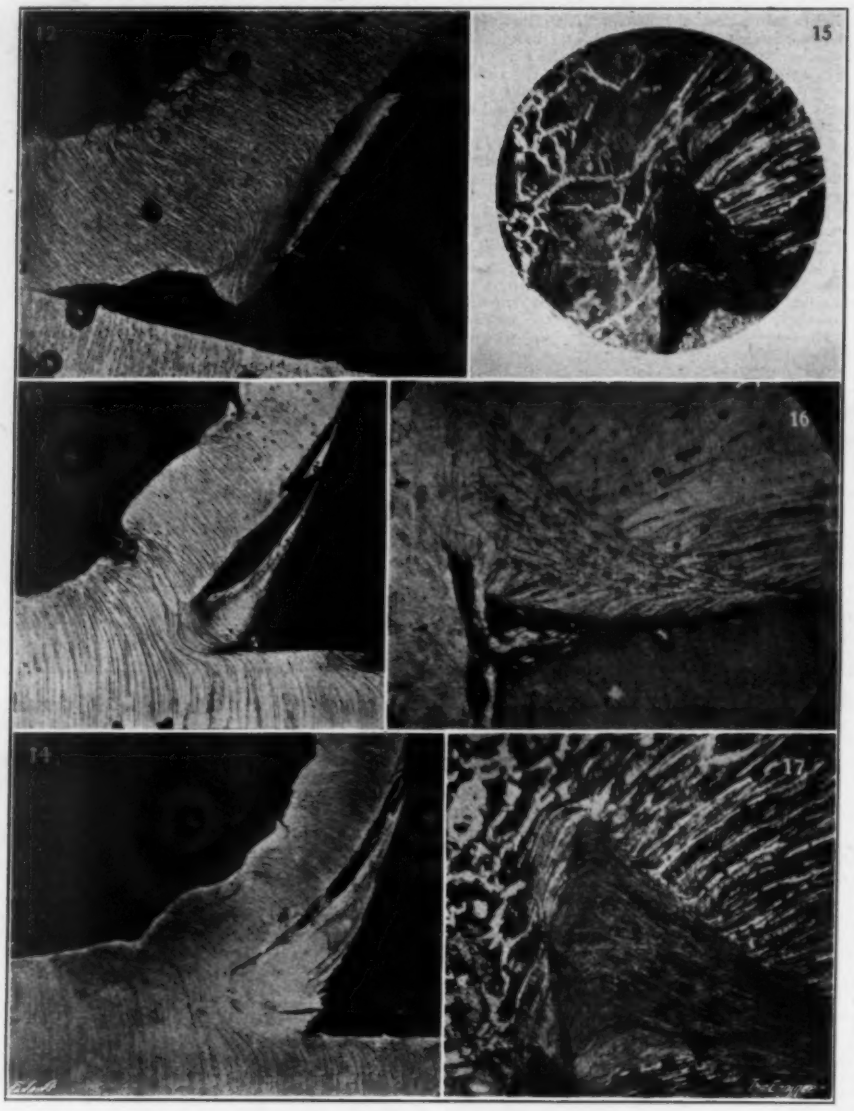
Figs. 15 and 16 show a later stage where the built-up edge actually surrounds the nose of the tool, while in Fig. 17 the completed edge, built up of innumerable layers and of almost razor-like sharpness, is cleaving a path through the solid steel. Professor Coker has shown that the zone of separation is in a state of tension, and the edge may be regarded as severing metal which is already stretched almost to the breaking point.

The built-up edge is the actual cutting implement, the tool merely serving to support it. It is much harder than the metal it is cutting. Thus in mild steel A the original hardness was 21·4, the hardness in the zone of separation 30, the maximum hardness of the chip 36, and the hardness of the built-up edge 44 (440*B*). In stainless steel C the hardness of the built-up edge was 53·4 (534*B*).

As to the manner in which the successive layers are united, Professor Gerald Stoney has pointed out that welding can take place at quite moderate temperatures between clean metal surfaces under heavy pressure, and it is probable that the edge is a welded structure.

Its cutting angle is much more acute than that of the tool which supports it, and must be assumed to be the angle best suited for cutting the particular metal under conditions as to speed, feed, and so forth, in which it is formed. The tool angle might be inferred to be unimportant, since the tool does no cutting, but actually the top rake angle of the tool determines the angle of incidence of the chip, and thus influences the pressure and the rate at which the chip wears away the tool surface behind the built-up edge, this being the ultimate cause of failure of the tool. Dr. Klopstock has proposed to lessen the angle of incidence without unduly weakening the tool by forming a hollow in the upper surface where the chip impinges.

This investigation has not been extended to acute-angled knife tools.



FIGS. 12 TO 17—BUILT-UP EDGE IN STAINLESS IRON B (FIG. 12), STAINLESS STEEL (FIGS. 13 AND 14), AND MILD STEEL (FIGS. 15, 16 AND 17)

Temperatures Generated in Cutting Metals.

In a paper on "The Measurement of Cutting Temperatures" the author has shown that the temperatures generated by tools cutting steel under normal conditions are very high, even when the operation is instantaneous as in the blow of a chisel, or when the tool and the work are flooded with oil or water. The method adopted for measuring cutting temperatures was that of the "tool-work thermo-couple." The tool and the work being of different metals, as stellite and mild steel, they were treated as the two elements of a thermo-couple, the tool being insulated with mica, and the thermo-electric voltage generated by the cutting temperature being measured with a millivoltmeter whose terminals were connected to the tool and to a convenient part of the machine.

Two diagrams are reproduced from this paper, Fig. 18 showing the temperatures generated on the tool steel testing machine in which a cut $^{1}/_{16}$in. wide by 0·0012in. deep is taken on the end of a steel test tube, and Fig. 19 giving the temperatures generated in cutting a mild steel bar on the bar lathe, the cut being $\frac{1}{16}$in. deep and the feed 0·023in. It will be seen from Fig. 18 that a temperature of 500 deg. Cent. (932 deg. Fah.) was generated by the tool taking a cut a thousandth of an inch deep at a speed of 200ft. per minute when the tool was flooded with water, and a temperature of 700 deg. Cent. (1292 deg. Fah.) when cutting dry under the same conditions. On the bar lathe temperatures of over 500 deg. Cent. were measured when cutting with oil or water under normal workshop conditions. The instantaneous temperature generated at the edge of a file cutting chisel was found to be 490 deg. Cent. (914 deg. Fah.), the voltage in this case being measured with a string galvanometer.

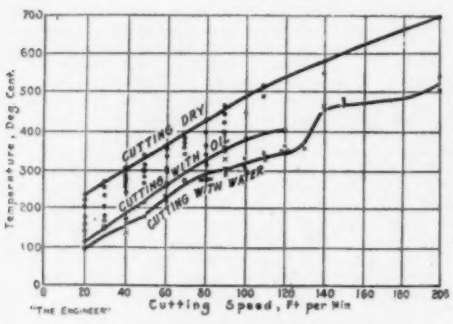


FIG. 18—TEMPERATURES GENERATED ON TOOL STEEL TESTING MACHINE

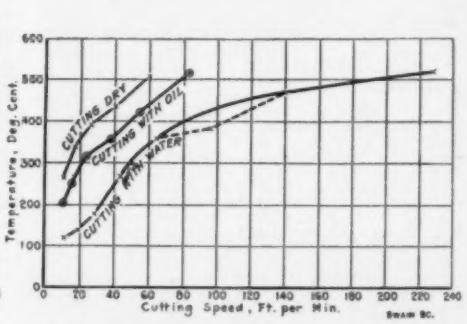


FIG. 19—CUTTING TEMPERATURES ON BAR LATHE (CUT $\frac{1}{16}$in. DEEP, TRAVERSE 43 PER INCH, VARIABLE SPEED)

The occurrence of these high temperatures under normal working conditions having been demonstrated, it is necessary to refer to the probable distribution of temperature.

The temperature measured by the tool work thermo-couple is necessarily that at a point or area of contact between the tool and the work material. Such contact always takes place where the chip impinges on the top face of the tool, a little distance behind the edge, and it does not necessarily take place elsewhere. It is reasonable to suppose then that the temperature measured by the tool work thermo-couple is the temperature between the tool and the chip, and that this is the maximum cutting temperature. It is the tool temperature—the temperature the tool has to withstand without becoming soft—and is therefore of supreme significance in relation to the hot hardness of the tool, which, however, is not now under consideration. The temperature in the work material results from the molecular friction due to deformation, and naturally increases from a minimum in the undeformed body of the bar, which is nearly cold, through a higher temperature where deformation commences considerably ahead of the tool, and so gradually rising, as the degree of deformation increases, to the zone where separation of the chip commences, rising further as the separated chip is crushed and bent back, and reaching a maximum where the already heated chip passes over the tool under heavy pressure. It is evident, then, that there is, properly speaking, no work temperature, but a temperature gradient in the work. The separation of the chip takes place somewhere on this gradient, but the actual temperature where separation is taking place cannot at present be measured. Reasons will be given for believing that it can be inferred with considerable accuracy, but for the present it must suffice to say that the separation of the chip takes place at some temperature intermediate between that of the cold bar and that of the very hot area of contact of chip and tool.

The existence of the temperature gradient may be inferred from a study of the progressive deformation and the gradual increase of hardness illustrated in Figs. 1 to 6. Its existence may be visually demonstrated by observing the colouration of a chip attached to a bar when the lathe has been suddenly stopped. The colouration will be seen to commence in the region ahead of the tool where some deformation has already taken place, and to deepen progressively to a maximum in a portion of the chip which has travelled some distance from the tool.

(To be continued).

PERSONAL AND BUSINESS ANNOUNCEMENTS.

FERRANTI, Ltd., of Hollinwood, Lancs., and London, asks us to announce that Mr. G. L. Porter, A.M.I.E.E., late of Messrs. Merz and McLellan, has joined its staff as advisory engineer.

THE ENGINEERING AND COMMERCIAL COPYING COMPANY, of 137, Victoria-street, Westminster, S.W. 1, asks us to announce that it has opened a City branch at 78, Queen Victoria-street, London, E.C. 4, by arrangement with Hodges Bennett and Co., Ltd.

MR. J. A. L. WADDELL asks us to announce that he has formed a partnership with his associate engineer, Mr. Shortridge Hardesty, under the name of Waddell and Hardesty, consulting engineers, 150, Broadway, New York City, U.S.A.

DOWDINGS' MACHINE TOOL COMPANY, Ltd., of Bush House, Aldwych, London, W.C. 2, asks us to announce that it has been appointed the selling agent in Great Britain for the Oscilloscope, which is manufactured by Baird and Tatlock (London), Ltd., for the New Oscilloscope Company, Ltd., of Westminster, which is the sole proprietor. The same company asks us to announce that Mr. Ivan M. Tweedy, B.Sc. (Eng.), A.M.I.N.A., late assistant works manager at the Neptune Works of Swan, Hunter and Wigham Richardson, Ltd., Newcastle-on-Tyne, has joined its Board of Directors in an active capacity.

JOHN AND EDWIN WRIGHT, Ltd., of Birmingham, ask us to announce that the decision of their directors and shareholders to change the name of the company to Wrights Ropes, Ltd., having been sanctioned by the Board of Trade, the change of name took place as from January 29th. The constitution, directorate and business policy of the company remain entirely unchanged.

T.B.D.'s FOR ROUMANIA.—We learn with interest and pleasure that John I. Thornycroft and Co., Ltd., has been commissioned to supply the designs for the two new torpedo-boat destroyers to be built in Italy for the Roumanian Government. Although the constructional work is not coming to this country, it is satisfactory to know that British naval architecture is still pre-ferred for these highly specialised types of naval vessels.

INSTITUTION OF NAVAL ARCHITECTS.—The annual general meetings of the Institution of Naval Architects will take place on Wednesday, April 6th, and the two following days, in the Lecture Hall of the Royal Society of Arts, John-street, Adelphi, W.C. 2. The President, the Duke of Northumberland, K.G., will occupy the chair. The annual dinner will be given on Wednesday, April 6th, at 7.30 p.m., in the Grand Hall, Connaught Rooms, Great Queen-street, Kingsway, W.C. It is proposed to hold a summer meeting in Cambridge on July 12th to 14th, and the University authorities have offered to grant facilities for that purpose. Arrangements will also be made to visit engineering establishments at Bedford and Ipswich at the conclusion of the meetings in Cambridge.

THE IRON AND STEEL INSTITUTE.—The annual general meeting of the Iron and Steel Institute will take place on Thursday and Friday, May 5th and 6th, at the House of the Institution of Civil Engineers, Great George-street, London, S.W. The annual dinner will be held on the evening of Thursday, May 5th, at the Connaught Rooms, Great Queen-street, W.C. 2. Members are reminded that in March the Council is prepared to consider applications for grants from the Carnegie Fund, in aid of research work on some subject of practical importance relating to the metallurgy of iron and steel, or allied subjects. Special-application forms can be obtained from the office of the Institute. The results of research work must be communicated to the Institute in the form of a report. The Williams Prize, founded in 1926 by Mr. Illtyd Williams, is offered for award by the Council to the author or authors—being of British nationality—of the paper that is adjudged to be the best practical paper presented to the Institute and accepted for publication at any general meeting during the year. The prize is approximately of the value of £100, and to be eligible for the award authors of papers coming within the scope of the scheme must be regularly employed in a British iron and steel works, and hold a position not superior to that of manager of any one technical department in such a works.

Provincial Letters.

THE MIDLANDS AND STAFFORDSHIRE.

(From our own Correspondent.)

Market Situation.

THE iron and steel position in the Midlands and Staffordshire shows little alteration on the week, and on 'Change in Birmingham to-day—Thursday—attempts at business proved almost vain. The market conditions are still too unsettled. Fuel values are high and that is all against any easing of iron and steel quotations. Buying continues in the main only for immediate needs, and few forward contracts are being entered into. Additional furnaces and mills are now turning out material, but they are largely occupied with arrears of orders left over from last year. Only a small amount of new business is being received by Midland producers.

Staffordshire Bar Iron.

There has been no change during the past week in the situation in the Staffordshire finished iron industry. The mills are not badly off for orders. Indeed, the marked bar houses continue busily occupied, and their rate is maintained without difficulty at £14 10s. The improved demand for chain and cable iron continues. Crown bars are quoted at £12 10s. upwards, and nut and bolt iron at £11 upwards. For the nut and bolt trade, which is busier than recently, a large tonnage continues to be delivered in Darlaston from abroad. Continental prices are generally a shade easier. There is a good call for iron tube strip, many Midland works being now busily engaged making up for lost time.

Raw Iron.

There is little activity in the raw iron department. Values both of foundry and forge material show no weakness and consumers are not disposed to buy more than they actually need for immediate consumption at present rates. Foundrymen are more concerned about getting fulfilment of old contracts than in arranging new business. The latter, they declare, can safely be left to take care of itself. Midland pig iron prices show no alteration. Derbyshire foundry is £4 5s., Northamptonshire £4 to £4 2s. 6d., and Staffordshire £4 7s. 6d. Forge qualities are receiving no attention. Hematite irons are offered more freely. East Coast makers want about £4 7s. at furnaces for No. 3, but West Coast competitors are prepared to accept somewhat less. Basic pig is quoted at about £4. A general resumption of buying is not anticipated until a lowering of fuel values has brought down raw iron quotations. The Northamptonshire blast-furnace owners and mine owners and the trade unions concerned passed at a recent meeting a resolution expressing apprehension at the serious increase in transport charges, and urging that legislation should be introduced to prevent serious damage being occasioned to one of the vital industries of the country.

Steel.

Business in steel continues fairly bright, but it is difficult in existing conditions to measure the strength of effective demand. In the main lines, prices remain unaltered. Production costs maintain them against any disintegrating effects. Steel mills are said to be making full output, and supplies are coming through better. Heavy steel—such as angles, joists and sections—is difficult to obtain, although the lighter material can now be had. Plates are in better supply, some of the mills now being able to promise reasonably early delivery. They have much pre-strike business yet to complete. Comparatively few soft billets are coming forward from native sources. Heavy steel scrap is on the basis of £3 7s. 6d., attempts to obtain £3 10s. being unsuccessful. Continental material is offered pretty freely, and Birmingham merchants report fairly heavy bookings. Continental joists can be obtained at £5 10s. Antwerp, or probably a little less, and the foreign maker is out for all the business he can capture, pending the recovery of British industry. Belgian No. 3 iron can now be had at £6 5s., sheet bars are £6, and billets £5 15s. French and Belgian mills, it is reported, are not as well situated for orders as they were a month ago.

Cheaper Sheets.

The decline in sheet values continues. It had been thought when they stood firm for a few weeks at £16 that bottom had been reached. Such, however, did not prove to be the case. The full order books of three months ago have become bare now, and millowners are very anxious to make outlets for their production. Most of the chief overseas markets have gone quiet, and demand from native sources is not large. Under these circumstances, district manufacturers have further reduced quotations. This week they were in many instances prepared to accept as low as £15 15s. per ton for 24 gauge galvanised corrugateds. A few mills asked £15 17s. 6d., but they failed to find purchasers. It was stated that for good export orders mills would accept even lower rates.

Fuel.

Although fuel supplies are this week a little easier, and in certain branches prices have given way a little, there is as yet no sign of such a depreciation of fuel values as would lead manufacturers to place forward business. Blast-furnace coke is still quoted round 20s. at ovens, a price which would be almost prohibitive if there were not old contracts at 14s. or 15s. to set against it. There has been a fall in foundry coke quotations, while slack prices also are coming down. Sales have been effected in exceptional cases at 9s. But taken all round fuel remains firm. There can be no doubt but that it is now the settled policy of most consumers of iron and steel to cut down their purchases to the minimum, so that they may be able to ensure that reductions in fuel shall be promptly reflected in the prices of iron and steel.

Ironworkers' Wages.

Wages of ironworkers in the Midlands, regulated by the sliding scale under the Midland Iron and Steel Wages Board, will remain unaltered at 60 per cent. above the basis of 13s. 6d. per ton until April 2nd.

The Chain Trade.

Some interesting details of the position of the chain and anchor industry are to be found in the annual report of the South Staffordshire Chainmakers' and Strikers' Association, issued by the general secretary, Mr. C. H. Sitch. Alluding to the fact that several reforms which are long overdue in the trade have not been tackled, owing to its depressed condition, Mr. Sitch points out that for the last three years nearly 40 per cent. of the members of the Association have been unemployed, and this figure rose to nearly 70 per cent. during the mining stoppage. These figures had now fallen, but there were still large numbers of the men totally out of work. The serious falling off of trade with the export markets is shown by the fact that in 1924 16,213 tons of chains and anchors were exported, but in 1925 the figure fell to 15,552 tons, and last year to 13,803 tons. In 1913 the exports totalled 30,000 tons. After stating that the trade depended on the prosperity of the shipbuilding industry, and pointing out that the British output in shipbuilding last year was only 38 per cent., as compared with 50 per cent. in 1925, 64 per cent. in 1924, and 58 per cent. in 1913, the report goes on to state that these figures did not give much ground for hope of better times in the chain trade. A large number of contracts had, however, been placed with shipbuilding firms during the past few months, and as there were arrears of work caused through the industrial dispute of 1926 to wipe off the prospects of the immediate future for the trade were rather bright.

Rolling Stock.

Rolling stock builders of the Midlands and Black Country are well employed, and have enough work to keep them busy for months ahead, but production is hampered by shortage of raw materials and fuel. Railway carriage and wagon builders are, however, gradually expanding their output week by week. There is a good amount of work awaiting execution, both in the carriage and wagon departments. Contracts are going through for new rolling stock required in connection with developments on home railways, but a goodly proportion of the coaches and wagons being made are being sent abroad.

Use of 20-Ton Railway Trucks.

Midland industrialists are paying considerable attention to the 5 per cent. rebate on the carriage charges on coal, roadstone and iron ore offered by the Great Western Railway Company to all traders who use 20-ton wagons on its system. It is considered that local firms may take advantage of the 1100 20-ton wagons which have been built for hire to traders. The advantages claimed for the 20-ton wagon, which was recommended by the Coal Commission, include saving in cost of construction and maintenance, increased rate of shipment, and increase in paying load.

South Derbyshire Coal Agreement.

The district agreement for the South Derbyshire coalfield was signed on Thursday last. Under it, the percentage addition to basis rates of wages will be determined by ascertained results, the ascertained figure coming into operation next July. Up to that date the owners offered the minimum percentage of 52·5. The minimum percentage afterwards will be 35. The lowest wage for lower-paid men will be 7s. 9d. per day underground and 7s. 5d. on the surface. The hours of work will be eight per day, with a three-quarter shift on Saturday when necessary. Twenty minutes will be allowed for meal time.

Bridge and Steelwork Contracts.

The Horseley Bridge and Engineering Company, Ltd., of Tipton, Staffordshire, has received contracts from the Crown Agents for the Colonies for ten 100ft. through spans and other bridge work of approximately 1000 tons weight for the Federated Malay States Railways, and for a 400-ton slipway jetty, 132ft. long and 15ft. wide, for erection at Bathurst, Gambia. Other contracts recently secured by the Horseley Bridge and Engineering Company are from the Southern Railway for a bridge, 124ft. long, over the river Medway at Maidstone, and the steel work for a new covered way to the extension of a platform at Guildford Station.

Electrical Equipment Order.

The General Electric Company, Ltd., of Birmingham, has, it is understood, been awarded by the London Electric Railway an order for the complete motor and control equipment for sixty-four motor coaches and forty-eight trailer coaches. This is the fourth consecutive order received by these manufacturers from the London Electric Railway, and the total equipment comprised in these orders is for 159 motor coaches, 78 driving trailer coaches, and 103 trailer coaches.

Unemployment.

That trade is improving in this district is evidenced by the latest unemployment returns, which show that in the Midlands area there are now totally unemployed 157,702, or 10,282 less than a week ago. My last letter recorded a drop of 23,736 in the number of unemployed in the previous two weeks, so that it would appear the re-absorption into industry is not a flash in the pan, but something which may be expected to continue with more or less strength. In the Birmingham area alone there was a drop last week of 1520.

LANCASHIRE.

(From our own Correspondents.)

MANCHESTER.

Power Demands of the Future.

MANCHESTER'S demands for electric power in the next ten years or less will exceed the maximum capacity of the city's existing power station sites. That is one of the important conclusions reached by Mr. H. C. Lamb, chief electrical engineer and manager, in a report to the Electricity Committee of the City Council on the application, so far as Manchester is concerned, of the Electricity Supply Act. It will be sound policy, in Mr. Lamb's opinion, for the Committee to extend the Barton power station to the full capacity of the site when the demand for electricity justifies it, whether the demand comes from the Central Board or from Manchester's own consumers. On the question of present costs of generating plant, Mr. Lamb says that recent contracts made by the Committee have shown that plant can now be purchased and buildings constructed at only half the cost of the original Barton installation, the effect of such extensions, therefore, being to reduce the average capital charges per unit of output. Whilst an immediate reduction in the price of electricity is not expected to follow the operation of the new Act, it is pointed out that a steadily falling price has always followed increased use, together with improved methods of generation and distribution.

Continental Competition.

Sir Christopher T. Needham, who is well known in the iron and steel trades, ably reviewed the position from the point of view of continental competition in the course of his address as chairman at the annual meeting in Manchester of the District Bank. Competition from continental iron and steel producers, so far as it was due to inflated currencies, had, he said, decreased now that the German and Belgian currencies had been stabilised and the French currency placed, at any rate for the time being, on a settled basis. The wage level on the Continent was somewhat higher, with the result that the margin between continental and British production costs in iron and steel was narrower. There was, he pointed out, still a substantial disparity caused by the difference in the standard of living and the longer working hours in continental countries, and their export prices were below the cost of production in this country in many of the less finished products of the iron and steel trades. Reference to the state of the Lancashire engineering trades was made by Mr. R. M. Holland-Martin, chairman of the Bank of Liverpool and Martins, at the annual meeting in Liverpool. The engineering trade, he pointed out, had suffered as much as any from the effects of the coal stoppage. Makers of spinning machinery had had a very bad year, though makers of weaving machinery had been busy. The machine tool trade had been badly hit, but, he said, it was hoped that with the revival in the shipbuilding industry there would be a general demand for the new and improved machines necessary if bigger output and more economical working were to be obtained.

Underground Railway Scheme.

The special committee of the Manchester City Council which is investigating the possibility of an underground tube railway system, has gone a stage further in its decision to communicate with Salford and Stretford and other neighbouring authorities in order to obtain their co-operation in a scheme which would mean tubes beyond the immediate centre of the city and into and beyond the suburbs. It is estimated that the cost of excavation alone would be round about a quarter of a million a mile.

Automatic Telephone Developments.

Progress in the installation of automatic telephone exchanges in the North-Western District, including Manchester, is indicated in an official report just issued. In the important areas of Preston and Southport active preparations are well in hand both in the towns themselves and in the outside areas of each. The Burnley exchange is expected to be in active operation within the next month or two, and a beginning will shortly be made in the Rochdale area, whilst negotiations are proceeding for the acquisition of a site for a building to accommodate the projected automatic exchange in Wigan. Extensions to the existing system in Blackburn have been carried out to meet the growing demand. The report states that the number of telephones in use in the North-Western District at the end of September last was 54,721, a net increase for the year of 4683, or 9·4 per cent.

The Guaranteed Day.

The Manchester No. 11 Branch of the National Union of Railwaymen has passed a resolution instructing its executive council that in the negotiations for a reinstatement of a guaranteed week it must not countenance the taking away of the guaranteed day. A demand is put forward for the return to all the conditions and agreements in force prior to the coal dispute.

Grain Handling Equipment.

Henry Simon, Ltd., engineers, Manchester, have received an important contract for grain handling equipment and electric power plant from the Bristol Docks Committee for service at Avonmouth Docks. The same firm, it may be recalled, recently secured a contract for similar plant from the Santos Dock Company, Brazil.

Non-ferrous Metals.

Tin and spelter have recovered a fair amount of strength compared with a week ago, whilst lead also has effected a certain degree of recovery, although to a lesser extent, copper being on a slightly lower level. In the case of tin the market has been a particularly fluctuating one, and under bearish influences a good deal of ground was lost, although since the market opened this week there has been a marked improvement from the worse and on

balance prices at the time of writing compared with a week ago are from £2 to £3 per ton better. Demand has been on a moderate scale during the week and there are expressions of continued faith in certain quarters in the strength of the statistical position. Business in copper has been quiet from all directions, sellers being much more in evidence than buyers, with the result that values, although not appreciably changed compared with this time last week, are on a slightly lower basis. Lead has attracted a moderate amount of interest from consumers and prices close a few shillings better than they were. Spelter is roughly £1 a ton up on the week and at times quite a fair volume of business has been done.

Iron.

Pig iron makers have had little to congratulate themselves on so far as additional orders are concerned, and consumers, pending lower quotations, are obviously content to mark time and to buy as sparingly as possible. Two factors which tend to operate against cheaper pig iron for the time being are the increased railway charges, which in the aggregate make quite an appreciable difference to production costs at the blast-furnaces, and the continued firmness of coke, for supplies of which pig iron producers are compelled to pay prices much in advance of those ruling before the coal strike. Moreover, the position has not yet been reached when available supplies can be said to exceed the orders awaiting delivery, and in the case of certain varieties, particularly Middlesbrough, there is still a scarcity. Midland irons—Derbyshire and Staffordshire brands—are quoted this week for delivery into this district at about 93s. per ton, with Middlesbrough in short supply and nominal at 95s., West Coast hematite at 98s., and Scottish No. 3 at 110s. to 112s. 6d. Bar iron remains quiet in spite of the lower range of prices, Crown quality offering at £11 15s. per ton and seconds at £10 15s.

Steel.

Most sellers on this market report a falling off in the demand for steel, but values maintain their firmness, with boiler plates quoted at about £11 10s. per ton, ship and tank plates at up to £9 per ton, joists and sections at £7 17s. 6d. to £8 2s. 6d., basic bars at £9 to £9 5s., ordinary acid wire billets at £11 per ton, and special quality at £12 10s. per ton. Galvanised sheets have shown a further pronounced easing off on this market, although the lower prices seem to have stimulated inquiry from some of the export outlets, notably from the East. Current values here are about £15 10s. per ton f.o.b. for the 24-gauge sheets. With the further weakness shown in continental steels since last report prices quoted for these materials have come still closer to pre-strike levels, although buyers continue their attitude of caution and demand has been slow. Ordinary plates are now being offered at £7 2s. 6d., Siemens plates at £7 5s., joists at £6 2s. 6d., steel bars at £6 2s. 6d., sheet bars at £5 10s., billets at £5 5s., and wire rods at £6 15s. to £7 per ton for net cash against shipping documents, delivered to buyers' works in the Manchester district.

Scrap.

Non-ferrous metal scrap remains in limited demand, but values show little change since last week, heavy yellow brass being offered at £44, lead at £26 10s., zinc at £25 to £26, clean light copper at £54, selected gun-metal scrap at £51, and brass rod turnings at £39 for graded qualities to buyers' works.

BARROW-IN-FURNESS.

Hematite.

The production of hematite pig iron continues on a bigger scale than has obtained for over a couple of years past and there is every sign of the tonnage increasing, for a further furnace is expected to be put in in Cumberland in the early future. The market is quiet and probably prices ruling at present have something to do with that. One of the drawbacks at present is undoubtedly the high cost of fuel. This applies particularly to coke. Prices might be more tempting if coke came down in price. In the meantime customers are hesitating about forward orders. The increase in the railway rates is also disturbing. A fair proportion of the present output of iron is of refined quality. The Backbarrow Company continues at full output of special iron suitable for malleable iron users and the demand continues to be good. Steel departments are taking a considerable amount of iron at Barrow and Workington now.

Iron Ore.

The iron ore mines in the district are generally experiencing better times, and it is hoped that outside trade will develop further. Most ore is being raised in the Cumberland districts, the Florence Pit being particularly active. Foreign ore is now in fair demand and imports are regular.

Steel.

Although the steel works have orders for rails, sleepers, &c., to keep them going for a matter of six months hopes are expressed that further orders may be secured to maintain regular running. The steel market is not very brisk, but there are signs of a few orders being booked ere the present contracts are completed. The hoop mills are fully booked up and are assured of regular running.

Electricity.

The Barrow Corporation sent a deputation to London to interview the Electricity Commissioners regarding permission to enlarge the present power-house at a cost of £60,000. The present power station is inadequate. It is understood that the Commissioners have informed the deputation that they are prepared to agree to the proposition providing that the Corporation is unable to obtain power from Vickers Ltd., who possess a very large modern equipment, at a lower rate per unit than it would cost to produce from the proposed extension. The Corporation is inclined to think that it could produce the current as cheaply as, if not more cheaply than, it could obtain it from Messrs. Vickers. Further negotiations with the Electricity Commissioners will follow.

SHEFFIELD.

(From our own Correspondent.)

Increased Steel Production.

THE production of open-hearth steel in this district at present is on a larger scale than at any time during the past three years. Out of a total of about ninety furnaces, some fifty are at work. It is usual to have a proportion idle for repair, so that the present output may be considered as equal to about two-thirds of the district's capacity, which is twice as much as the average of 1925. This is very satisfactory from the point of view of immediate trade, but some anxiety is felt with regard to the future. There is enough work on hand to last another month or two, but it consists for the most part of contracts which were placed before or during the stoppage. The quantity of new work coming forward is small, and January was a disappointing month in regard to bookings of pig iron, billets and other materials. It is thought that consumers are waiting for prices to come down. At present pig iron is costing about £1 per ton more than it did in April, but there is the prospect of a considerable reduction in the early future, which should be reflected in the price of semi-finished steel, so that it is not to be wondered at if users are holding their orders back. It is hoped that the present lull is merely due to a temporary falling off in the demand. At the same time, the fact cannot be overlooked that continental steel prices are falling rapidly, and that French and Belgian makers are putting forth strong efforts to attract business.

More Armament Work.

The *Journal* of the Sheffield Chamber of Commerce for January takes a cheerful view of the situation, and states that in spite of one or two dark clouds, the industrial weather looks more promising than it has done for several years. The interesting statement is made that there is more naval and general armament work on hand in the district than at any previous time since the war. The *Journal* goes on to say: "Among the favourable factors for our heavy trades a distinct revival in shipbuilding is notable. In the last six weeks more fresh tonnage has been ordered than in the twelve months prior to, say, the middle of November. There is no boom yet, but there is pronounced revival. Railway orders continue to expand, and bridge and general structural steels, including colliery equipments, are growing lines. Heavy wire ropes, cranes, dredgers, excavators, &c., are also in increasing request."

Leeds University's Building Scheme.

An extension scheme of the first importance, to cost no less than £500,000, is projected by the authorities of Leeds University, and plans have now been accepted. The first premium of £500 has been awarded to Messrs. Lanchester, Lucas and Lodge, of London; and the second, of £300, to Mr. John C. Procter, a Leeds architect. The assessor was Mr. P. S. Worthington. According to the plan which has gained the first premium, the library will be the centre of the whole conception, and will be a fine domed structure. Grouped round it, and within easy reach, will be the various schools, with well-lighted and direct communicating corridors, linking up every part of the buildings. Every department will be readily accessible from the Students' Court, which, says the assessor, "is in itself one of the great features of the scheme as a centre of University life and one of considerable importance in this climate." The new buildings will be dominated by a fine central tower.

Cutlery and Plate.

In the cutlery and plate trades the year opened with a business spurt, which was very encouraging, but it soon came to an end. There are now many complaints of bad trade, and, generally speaking, the present position is not as good as that of a year ago. The report from merchants, stores and shops in London is that sales over the counter are even below those of the strike period, and that the briskness of the Christmas season appears to have been followed by a wave of economy. There is a fair demand for pen and pocket knives of best quality, but it is the general opinion of the trade that sales of such goods ought to be larger than they have been for several years past. The demands from overseas are on the quiet side, as is generally the case during the first two months of the year. The Admiralty and War Office are at present inviting their annual tenders for cutlery, tools and other steel goods. The Army Clothing Department requires 17,500 table knives and 70,000 unplated table spoons, the metal of which is to contain 18 per cent. of nickel. The wants of the Army Ordnance Department include 1700 carving forks, 2560 carving knives, 2300 cooks' knives, 6000 shovels, 6200 stable and other forks, 190 vices and 340 tenon saws. The Admiralty asks for tenders for 11,000 hollow-ground razors of the ordinary pattern—an indication that the Department is not adopting the safety razor, as the War Office has done.

A New Drive for Tube Mills.

Edgar Allen and Co., Ltd., of the Imperial Steel Works, Tinsley, Sheffield, have become the sole licensees in this country, and in the British Colonies and Dominions, for the "Centra" drive for tube mills and combination mills for crushing and grinding ores and other hard substances. The advantages claimed for this improved method of driving the mills include saving in maintenance costs, less lubrication costs, and reduction in power consumption due to increased efficiency and smooth running. The drive is also intended for use in conjunction with a high-speed motor, with its consequent higher efficiency and power factor, as compared with medium or low-speed motors in general use in tube mills.

University and Trade.

The Applied Science Department of Sheffield University, which has been of enormous value to the various trades of the city for many years, has just started a new series of lectures for those engaged in several industries. In the case of the silver trade, the lectures will be confined to a study of the materials used, but in regard to other branches—rolling and forging, cutlery, file production and tool making—they will deal with methods of production and show the possibilities of applying modern machinery and principles. The lectures to foundrymen will relate to blue-prints and workshop drawings.

Colliery Developments.

It is expected that the new West Thorpe Colliery of J. and G. Wells, Ltd., at Killamarsh, will be developed considerably in the near future. Mr. T. Greensmith, the managing director of the company, speaking at the annual dinner of the officials, stated that Messrs. Wells anticipated building 600 houses at Killamarsh. Fifty were now in course of erection in the Upperthorpe district, and it was proposed to construct a new road from there to Highmoor. While this was being done, it was expected that the new colliery would be developed considerably, and that by the time the 600 houses were completed another 2000 men and boys would be employed there. An interesting piece of colliery engineering was mentioned by Mr. P. F. Day, of the Pinxton Collieries, Ltd., at the annual dinner of the Midland Counties Branch of the Institute of Mine Surveyors, at Mansfield last Saturday. He said that at the Pinxton collieries they had recently carried out an important drainage scheme, removing three-quarters of a million tons of water from old workings. The water was conveyed along a mile of underground pipes. The scheme had been completed without interfering with the working for a day. For this, a large measure of the success was due to Mr. G. Blood.

NORTH OF ENGLAND.

(From our own Correspondent.)

Engineering Works Reopening.

THE brighter outlook in industry generally is further indicated by the decision of Richardsons, Westgarth and Co., Ltd., to reopen their Middlesbrough and Sunderland works, which have been closed since about the middle of last year. The Hartlepool works of the firm have been kept in fairly steady operation, and are now so well occupied as to afford employment to about 900 men. A certain amount of overtime has been worked, and it has been considered desirable to divert a proportion of the work to Middlesbrough and Sunderland. Certain departments of these works will, therefore, be reopened during the next two or three weeks. Still more and more idle iron and steel-producing plant is being restarted. With another of the Dorman group of blast-furnaces to be relighted at the Port Clarence Works, the total number in this area will be increased to 45. Possibly two or even three more furnaces may be blown in during the present month.

Cleveland Iron Trade.

Although the rapid growth of production of Cleveland pig iron has been remarkable, output is still quite inadequate to current needs, and consumers have the greatest difficulty in securing supplies even of very small parcels. The fact that continental iron and steel prices are falling rapidly is having little effect so far as producers in this district are concerned. The scarcity of all classes of pig iron is so acute that makers have no need to consider the question of price cuts. If, however, the continental market continues to sag, the possibility of a renewal of the import of foreign iron cannot be entirely ignored. It is anticipated that before long the quantity of iron available for the home market should show a progressive improvement as a result of recent expansions of output, and in this respect it is significant that some of the makers are recognising their obligations by making deliveries under old contracts. This entails a big sacrifice on the part of the makers, as these old contracts were made on the basis of 70s. per ton for No. 3 G.M.B. Cleveland pig iron, a figure much below the cost of production. In view of the fall in continental pig iron prices, and the prospect of improved supplies at home, buyers are not disposed to make heavy forward commitments, but so long as ore and coke prices are maintained at their present levels, there seems to be little chance of any substantial cut in the price of pig iron. Moreover, makers are not inclined to sell below cost, as they did a year or more ago, and consequently they can only reduce prices as production costs fall. For any prompt supplies of No. 3 G.M.B. that are available, nothing below 85s. is named, but for the latter part of February 82s. 6d. is quoted. No. 1 Cleveland foundry iron is 82s. 6d; No. 4 foundry, 81s. 6d.; and No. 4 forge, 80s. 6d.

Hematite Pig Iron.

The position in the East Coast hematite pig iron trade is also very difficult. Eight blast-furnaces are now turning out iron, but much of it is hardly up to the standard of mixed numbers, and is going direct into the steel furnaces. Any prompt parcels of mixed numbers readily realise 90s. per ton, but possibly that figure might be shaded for a forward contract.

Ironmaking Materials.

Imports of foreign ore to the Tees last month totalled 59,616 tons. Works are now pressing for deliveries. Nominally best Rubio ore is about 22s. 3d. per ton c.i.f. Tees, but business can still be placed at 22s. Coke prices also incline to firmness. Supplies are still scarce, and about 26s. per ton might be taken as an average figure delivered at the works, though prices vary a good deal.

Manufactured Iron and Steel.

Quotations for manufactured iron and steel are steady, but buyers are hopeful of somewhat easier prices in view of the developments abroad, and are holding off in the hope of better terms. The lull in business continues, but works are well placed in regard to orders, and they will be kept busily employed well into the third quarter of next year.

Iron and Steel Trade Wages.

North of England iron and steel workers will suffer reductions in wages under ascertainments issued this week. The fall in the average net selling price of manufactured iron for the two months ending December 31st last involves under the sliding scale a reduction of 10 per cent. in puddling and other forge and mill wages. The steel smelters will also suffer a 2½ per cent. reduction in accordance with their sliding scale.

The Coal Trade.

There is no development in the demand for any class of coal, and the market throughout rules dull. A determined effort, however, is being made by the collieries to check the downward tendency in prices, particularly in the steam varieties. Since the middle of December best steams have dropped by 6s. a ton, and best gas by a similar amount, with other grades in proportion, and, therefore, the point has been reached, it is asserted, at which any further reduction would involve loss. It is felt that some semblance of stability spread over a few weeks would probably bring new business, which at present is being withheld in the expectation that prices will recede further. In the meantime the collieries are fairly well employed. The railway companies have made large purchases of coal lately, and during the current month the gas fuel collieries in Durham will be helped by the London gas companies taking the unexhausted portion of contracts arranged last year. Holders of steam coals are taking a stand against any concessions below 17s., but buyers hold off. Second steams and unscreened steams are quoted at 16s., but buyers hold for concessions, and transactions are in abeyance. On the Durham side, gas coal fitters are taking a more cheerful view of the prospects, and hold steadily to recent minimum values. Best qualities command 17s. 9d. to 18s.; secondary, 15s. 6d. to 16s. 6d.; and coking unscreened, 16s. 6d. to 17s. 6d. Durham unscreened bunkers meet with an improved demand and are steady, best at 17s. 6d., and seconds 16s. 6d. For the next fortnight, coke is well booked up and full daily output is readily cleared. For later delivery the demand is slow, and prices may not be easy to maintain at the present level. A weak coal market may mean cheaper coke and thus the mid-February positon is a little uncertain. Gas coke is quoted at 22s. 6d. to 23s. 6d., and patent foundry coke 24s. to 27s. 6d.

Iron and Steel Exports.

The exports of pig iron, manufactured iron and steel from the Cleveland district during January reached 41,348 tons, which is the highest monthly total since June last. Pig iron exports totalled 8178 tons, of which 1957 tons went to foreign destinations, while overseas shipments of manufactured iron and steel reached 25,002 tons.

SCOTLAND.

(From our own Correspondent.)

Shipbuilding.

THE steamer Reynolds, a cargo vessel of 5209 tons, built at Port-Glasgow for Glover Brothers, London, was the only vessel launched on the Clyde during January. The rate of production has slowed down through lack of materials, but a great improvement in that respect is expected by the middle of March. The outlook for this year and probably next year also is reckoned fairly satisfactory, provided nothing occurs to hinder operations. A number of contracts were held up during the coal strike, and builders now await the necessary materials to go ahead on them, and since the strike ended a considerable number of contracts have been placed. Consequently there is a large amount of work on hand. Inquiries are still being received, but very keen prices have to be named. The increased railway rates will probably retard the placing of new business, as the increased costs have made shipbuilders chary about accepting fresh contracts meantime. Recent contracts include the following:—A second cruiser of 10,000 tons for the Admiralty, two motor tankers of 15,600 tons each, a motor cargo vessel of 10,000 tons, a cargo steamer of 9400 tons, and one of 6000 tons, and a number of smaller craft.

Miners' Unemployment Benefit Test Case.

The chief umpire on the claim to unemployment benefit on behalf of 300 miners who were employed at a colliery near Glasgow has just announced his decision. The lower seams in the colliery were abandoned last June, whereupon the miners working these seams claimed unemployment benefit. The claim was refused by the local unemployment authorities and has been the subject of subsequent conferences between the secretary of the Lanarkshire Miners' Union and the chief umpire. The point at issue was whether the closure of a section of a pit meant that the men displaced thereby were genuinely unemployed. The Chief Umpire has now ordered the payment of benefit to the men concerned as from June 22nd last.

Ironworkers' Wages.

In view of the fact that the average net selling price of iron has been certified as £11 15s. 8·68d. per ton during November and December, the wages of ironworkers fall to be reduced by 2½ per cent.

Steel and Iron.

With conditions in the steel trade more or less unchanged prospects of extensive operations in the market are still comparatively obscure. Steel makers are, and will be for some time, busy on old contracts and are not seeking orders for early delivery, while many buyers are keeping out in the hope of a fall in prices. In view of the increased railway rates, on the other hand, steel makers have been considering the advisability of higher quotations, but have delayed their decision at present. Steel sheets have regular bookings and Indian buyers of the cheaper grades of galvanised sheets have benefited from the fall in the price of spelter. Bar iron makers report slow progress. Bar iron is in rather poor demand and the re-rolled steel departments are not so busy as they were a week or two ago. Re-rolled steel bars have been reduced in price and are now quoted £8 10s. per ton for home delivery.

Pig Iron.

Business in pig iron moves on recent lines. Steel makers are taking good deliveries of hematite against old contracts, but are not committing themselves to fresh engagements at present. Supplies of hematite are ample for all immediate requirements. Foundry qualities, however, are scarce. Stocks have been wiped out and producers find difficulty in obtaining the desired standard in quality. Prices are practically unchanged.

Coal.

Apart from a steadier tone in certain qualities of screened fuel, there is no change in the coal market. Firmness in these qualities is not attributable to increased turnover, but to the covering by shippers who have commitments abroad and to moderate output. Fresh export demands are few and collieries in Fifeshire and the Lothians are suffering accordingly. Shipments have been interfered with owing to a lack of empty wagons, and aggregate shipments are considerably less than they might be at 215,117 tons, against 216,619 in the preceding week and 225,009 tons in the same week last year. Washed nuts have improved somewhat owing to better home demands, but round fuels for industrial purposes are sagging.

WALES AND ADJOINING COUNTIES.

(From our own Correspondent.)

Coal Trade Position.

THE conditions in the steam coal trade continue to be far from satisfactory. The troubles of coalowners have been accentuated by the paucity of tonnage, the arrival of which has been delayed by the recent heavy gales. Steamers have gone right out of their original loading positions, and as a consequence numerous collieries have been unable to get quick clearance of their standing coals, and on a market none too well supplied with orders, salesmen have been compelled to make further concessions to buyers who can ship quickly. The outcome has been that exporters have been ready to bid up for prompt boats in the full expectation that they would be more than recompensed for the relatively higher freight rate by the reduction in the price of coals. This state of affairs is naturally to the disadvantage of those merchants who have c.i.f. commitments to execute, and who can see the freight market going against them almost daily. So far as can be seen, coals are likely to be very irregular for some time, as there is no material expansion in business for early loading, and the tonnage difficulty is one that is not likely to be overcome quickly. One item of especial interest so far as the coal trade is concerned is that the new conditions regarding work at the docks came into operation on Monday last. Instead of two consecutive shifts being worked—that is, from 6 a.m. to 2 p.m. and from 2 p.m. to 10 p.m.—two split shifts are adopted, viz., a day and night shift. The day shift is from 7 a.m. to 4 p.m., with two breaks of half an hour each for meals, and the night shift is from 8.30 p.m. to 5.30 a.m., with one hour break for meals. The start of this new arrangement has not apparently been a very satisfactory one, and at one or two of the ports in the Channel workmen and some of the employers do not appear to be very impressed with the change. No doubt in time the altered arrangements will operate more smoothly than is the case at present. The main argument for the new scheme is that the railway company will, as the result of the break between the two shifts, have ample time to marshal the traffic and that speedier work should be done. At the same time, many who are interested in the export trade contend that the present arrangement will not prove superior to the old conditions, for the reason that work during the night is as a rule much slower than at other times, and really to bring about quicker shipments the only solution is for work to be carried out all round the clock.

Coal Contracting.

It is probable that no year has been entered upon with less contracting done for coals than is the case this year. In previous years contracts for six or twelve months have as a rule been fixed up during November and December, but the abnormal conditions which have prevailed following upon the national coal stoppage have induced buyers to hold off. Collieries as a consequence are by no means as well placed as in previous years. Buyers have for the most part contented themselves with proceeding on a hand-to-mouth principle, but with coal prices now at a much lower level than was the case a few weeks ago, there are more inquiries on the market for supplies for delivery over the remainder of this year. The British Admiralty is reported to have contracted for coals over the remainder of this year, but the total is comparatively small, and is stated to be round about 100,000 tons. This is less than last year, and the price is currently reported to be about 22s. to 22s. 6d. per ton. One surprise is the fact that the Egyptian State Railways, which recently bought 100,000 metric tons of Welsh large steam coals at 31s. 11d. per ton, c.i.f. Alexandria, for delivery over February, March and April, have intimated that they are coming on the market for tenders for a further supply of 300,000 metric tons for delivery from March to September, but instead of asking for prices for the full quantity, it is understood that it is the intention to have three adjudications, viz., about March 1st, May 1st, and July 1st each for 100,000 tons. This is a very unusual procedure for these railways, and indicates that in their view unstable conditions are likely to prevail on the market for some time.

Transport Rates.

The Cardiff Chamber of Commerce has passed a resolution opposing the introduction of increased rail rates, the view being that it is a most inopportune time to saddle industry with additional burdens and that the railways should rather look for increased revenue by assisting to promote a larger volume of shipments.

Coalfield Items.

Reference was made last week to the decision of the workmen at the Cambrian Combine collieries to indulge in a strike every Monday until their alleged grievances were remedied by the management, but they have since then yielded to wiser counsel, and the executive for the district has decided to suspend such action pending investigation of the men's complaints. Work came to a standstill on Wednesday last week at the Aberaman Colliery, belonging to the Powell Duffryn Company, where a fortnight's notice had been served to the men. Although the men's leaders have endeavoured to persuade the management to agree to work being resumed on a day-to-day contract basis, the company has intimated that this would be too costly a procedure, and the colliery will be idle until trade justifies a resumption of work. About 1100 men are affected.

Ship Repairers and Boilermakers.

For quite a long time past ship repairers in the Bristol Channel have been negotiating with the various trade unions in order to bring about a revision of the working conditions in the industry so as to enable employers to compete more favourably for orders. Unfortunately at the end of last week it was officially announced that the negotiations between the employers and the Boilermakers' Society had broken down, the main cause being the refusal of the men to agree to overtime on a time and a-half basis as against double time, which has been in operation in this district.

Tin-plate Pool.

Tin-plate manufacturers in South Wales have decided to resuscitate the tin-plate "pool" scheme for the regulation of prices and output, and the date upon which it is to come into operation is March 28th next. The scheme provided for the payment of a certain sum per mill into the pool and the fixing of a specific output. For over-production 9d. per box was to be paid in and for under-production 1s. per box to be withdrawn from the pool. The scheme was left in abeyance when the general strike and coal stoppage occurred in May last; but it is hoped that its renewal will have the effect of stabilising the industry, which is making great efforts to recover the leeway which has been lost.

Dowlais Disaster.

As the result of the bursting of a furnace stove at the Dowlais works at Cardiff on Thursday evening last week three workmen lost their lives and several others were injured. According to the general manager, it is impossible to state what caused the unfortunate occurrence. Technically there was no explosion. The stove burst and caused a total collapse, and the loud report which gave the impression of an explosion was caused by the rush of released air. So complete is the ruin of the stove that the chances of getting at the cause of the disaster are probably entirely obliterated.

Current Business.

There is comparatively little fresh business passing for current shipment, and the market is extremely irregular. Apart from the scarcity of new business, the position of many collieries has been jeopardised by the fact that tonnage which should have put in an appearance has been badly delayed by the heavy gales which have prevailed. The market is weak for prompt coals, but this applies more particularly to large qualities, which are now about 23s. to 24s. for best Admiralty large, and 21s. to 22s. for ordinary descriptions. Owing to the irregular working of so many collieries supplies of small coals are not so plentiful, and prices are very steady for the superior qualities, which command up to 15s. 6d. There is no appreciable alteration in patent fuel, which stands at about 27s. 6d. to 29s. Pitwood is easier at 27s. 6d. to 28s. 6d.

CENTRAL MARINE ENGINE WORKS.—The apprentice advancement scheme of the Central Marine Engine Works, West Hartlepool, now in its twenty-fourth year, provides for an increase in wages for the following twelve months to those apprentices who obtain the required number of marks under three heads:—Grade "A," for 276 marks and above, 1s. per week; grade "B," for 259 marks to 275 marks, 9d. per week; grade "C," for 230 to 258 marks, 6d. per week. The maximum obtainable is 400, *i.e.*, 100 for timekeeping, 100 for conduct, 100 for workmanship, and 100 for success at classes. In addition to the awards, the evening class fees are refunded to those apprentices who are successful in the examinations. The results this year are an improvement upon the previous one. To the apprentice gaining the highest number of marks in his shop, and to those apprentices gaining an average of not less than 300 marks in two consecutive years, a "First Place" Certificate and "Merit" Certificates are awarded respectively. The results for the year ending December 31st, 1926, show that 49 per cent. of the total apprentices in the works have qualified for the awards. This percentage is an improvement upon the preceding year and is the highest recorded. An analysis of the awards shows that 13 per cent. gained awards under trade "A" (the highest), 6 per cent. under grade "B," and 30 per cent. under grade "C."

Current Prices for Metals and Fuels.

IRON ORE.

N.W. COAST—	
Native	18/6 to 21/-
(1) Spanish	18/6 to 21/-
(1) N. African	18/6 to 21/-
N.E. COAST—	
Native	18/- to 21/-
Foreign (c.i.f.)	22/-

PIG IRON.

	Home. £ s. d.	Export. £ s. d.
(2) SCOTLAND—		
Hematite	4 10 0	—
No. 1 Foundry	4 15 0 to 4 17 6	—
No. 3 Foundry	4 11 6 to 4 14 0	—
N.E. COAST—		
Hematite Mixed Nos.	(e) 4 10 0	4 10 0
No. 1	(e) 4 11 6	4 11 0
Cleveland—		
No. 1	(e) 4 7 6	4 8 0
Silicious Iron	(e) 4 7 6	4 8 0
No. 3 G.M.B.	(e) 4 2 6	4 3 0
No. 4 Foundry	(e) 4 1 6	4 2 0
No. 4 Forge	(e) 4 0 6	4 1 0
Mottled	(e) 4 0 0	4 0 6
White	(e) 4 0 0	4 0 6

(e) *Mid-February Delivery.*

MIDLANDS—		
(3) Staffs.—		
All-mine (Cold Blast)	—	—
North Staffs. Forge	4 0 0	—
„ „ Foundry	4 7 6	—
(3) Northampton—		
Foundry No. 3	4 0 0 to 4 2 6	
„ Forge	3 14 0	—
(3) Derbyshire—		
No. 3 Foundry	4 5 0	—
Forge	4 0 0	—
(3) Lincolnshire—		
No. 3 Foundry	4 5 0	—
No. 4 Forge	—	—
Basic	3 17 0 to 3 18 0	
(4) N.W. COAST—		
N. Lancs. and Cum.—		
Hematite Mixed Nos.	4 17 6 (a); 5 0 6 (b); 5 4 0 (c)	—

MANUFACTURED IRON.

	Home. £ s. d.	Export. £ s. d.
SCOTLAND—		
Crown Bars	11 15 0	11 10 0
Best	—	—
N.E. COAST—		
Common Bars	12 5 0	—
LANCS.—		
Crown Bars	11 15 0	—
Second Quality Bars	10 15 0	—
Hoops	14 0 0	—
S. YORKS.—		
Crown Bars	12 10 0	—
Best Bars	13 10 0	—
Hoops	14 10 0	—
MIDLANDS—		
Crown Bars	12 15 0	—
Marked Bars (Staffs.)	14 10 0	—
Nut and Bolt Bars	11 0 0 to 11 5 0	
Gas Tube Strip	12 10 0	—

STEEL.

	(6) Home. £ s. d.	(7) Export. £ s. d.
(5) SCOTLAND—		
Boiler Plates	11 0 0	—
Ship Plates, ½in. and up	8 7 6	7 0 0
Sections	7 17 6	6 5 0
Steel Sheets, under 3/16in. to ½in.	12 5 0 to 13 5 0	
Sheets (Gal. Cor. 24 B.G.)	— £16 0 0 to 17 0 0	

STEEL (*continued*).

N.E. COAST—	Home. £ s. d.	Export. £ s. d.
Ship Plates	8 7 6	—
Angles	7 17 6	—
Boiler Plates	12 10 0	—
Joists	7 17 6	—
Heavy Rails	8 10 0	—
Fish-plates	12 0 0	—
Channels	10 5 0	£9 to £9 5
Hard Billets	8 12 6	—
Soft Billets	7 12 6	—
N.W. COAST—		
BARROW—		
Heavy Rails	8 10 0†	—
Light Rails	8 15 0 to 9 0 0	
Billets	8 0 0 to 11 10 0†	
MANCHESTER—		
Bars (Round)	9 0 0	—
„ (Small Round)	9 5 0	—
Hoops (Baling)	11 0 0	11 0 0
„ (Soft Steel)	10 15 0	10 15 0
Plates	8 17 6 to 9 0 0	
„ (Lancs. Boiler)	11 10 0	—
SHEFFIELD—		
Siemens Acid Billets	11 0 0	—
Bessemer Billets	11 0 0	—
Hard Basic	9 2 6	—
Intermediate Basic	8 12 6	—
Soft Basic	7 15 0 to 8 0 0	
Hoops	12 0 0	—
Soft Wire Rods	10 0 0	—
MIDLANDS—		
Small Rolled Bars	8 15 0 to 9 0 0	
Billets and Sheet Bars	7 0 0 to 7 5 0	
Sheets (20 W.G.)	11 10 0 to 12 0 0	
Galv. Sheets, f.o.b. L'pool	15 15 0 to 15 17 6	
Angles	7 17 6 to 8 0 0	
Joists	7 17 6 to 8 0 0	
Tees	9 0 0	—
Bridge and Tank Plates	8 17 6 to 9 2 6	
Boiler Plates	11 10 0	—

NON-FERROUS METALS.

SWANSEA—	
Tin-plates, I.C., 20 by 14	19/9 to 20/6
Block Tin (cash)	295 15 0
„ (three months)	290 0 0
Copper (cash)	54 10 0
„ (three months)	55 0 0
Spanish Lead (cash)	26 16 3
„ (three months)	27 2 6
Spelter (cash)	29 13 9
„ (three months)	29 16 3
MANCHESTER—	
Copper, Best Selected Ingots	61 5 0
„ Electrolytic	61 7 6
„ Strong Sheets	88 0 0
„ Tubes (Basis Price) lb.	0 1 0½
Brass Tubes (Basis Price) lb.	0 11½
„ Condenser lb.	0 1 2
Lead, English	28 7 6
„ Foreign	26 15 0
Spelter	29 12 6
Aluminium (per ton)	£107

FERRO ALLOYS.

(*All prices now nominal.*)

	Per Ton.	Per Unit.
Tungsten Metal Powder	1/10 per lb.	
Ferro Tungsten	1/8 per lb.	
Ferro Chrome, 4 p.c. to 6 p.c. carbon	£23 0 0	7/8
„ „ 6 p.c. to 8 p.c. „	£22 0 0	7/3
„ „ 8 p.c. to 10 p.c. „	£20 17 0	6/6
„ „ Specially Refined		
„ „ Max. 2 p.c. carbon	£36 2 6	11/6
„ „ „ 1 p.c. „	£42 5 0	13/-
„ „ „ 0·70 p.c. carbon	£54 0 0	17/8
„ „ „ carbon free	1/5d. per lb.	
Metallic Chromium	3/3 per lb.	
Ferro Manganese (per ton)	£16 for home, £16 for export	
„ Silicon, 45 p.c. to 50 p.c.	£11 7 6 scale 5/- per unit	
„ „ 75 p.c.	£18 10 0 scale 6/- per unit	
„ Vanadium	14/6 per lb.	
„ Molybdenum	5/1 per lb.	
„ Titanium (carbon free)	0/11½ per lb.	
Nickel (per ton)	£170	
Cobalt	8/6 per lb.	

FUELS.

SCOTLAND.

(*Prices not stable.*)

LANARKSHIRE—	Export.
(f.o.b. Glasgow)—Steam	16/9
„ „ Ell	17/9
„ „ Splint	19/6 to 21/6
„ „ Trebles	20/6
„ „ Doubles	18/6
„ „ Singles	17/6
AYRSHIRE—	
(f.o.b. Ports)—Steam	17/6
„ „ Jewel	19/-
„ „ Trebles	21/-
FIFESHIRE—	
(f.o.b. Methil or Burntisland)—Steam	14/- to 16/-
Screened Navigation	22/6
Trebles	21/6 to 24/-
Doubles	18/-
Singles	16/6
LOTHIANS—	
(f.o.b. Leith)—Best Steam	15/9
Secondary Steam	15/-
Trebles	21/6
Doubles	18/6
Singles	16/-

ENGLAND.

(8) N.W. COAST—	
Steams	28/-
Household	*No quotation.*
Coke	32/6
NORTHUMBERLAND—	
Best Steams	16/6 to 17/-
Second Steams	15/6 to 16/-
Steam Smalls	11/-
Unscreened	15/-
Household	23/- to 30/-
DURHAM—	
Best Gas	18/-
Second	16/- to 16/3
Household	23/- to 30/-
Foundry Coke	25/-

SHEFFIELD—	Inland.
Best Hand-picked Branch	40/- —
Best Selected House Coal	34/- to 35/- —
Barnsley Best Silkstone	30/- to 32/- —
Derbyshire Best Brights	30/- to 32/- —
„ „ House	28/- to 30/- —
„ „ Large Nuts	26/- to 28/- —
„ „ Small	18/- to 21/- —
Yorkshire Hards	19/- to 21/- —
Derbyshire Hards	19/- to 21/- —
Rough Slacks	12/- to 12/6 —
Nutty Slacks	8/6 to 9/6 —
Smalls	3/- to 6/- —
Blast-furnace Coke (Inland)	20/- to 25/- at ovens.*
„ (Export)	f.o.b. 26/- to 27/-

(9) SOUTH WALES.

CARDIFF—	
Steam Coals :	
Best Smokeless Large	23/- to 24/-
Second „ „	22/- to 23/-
Best Dry Large	22/6 to 23/-
Ordinary Dry Large	21/6 to 22/-
Best Black Vein Large	22/3 to 22/9
Western Valley Large	22/- to 22/6
Best Eastern Valley Large	21/9 to 22/3
Ordinary „ „	21/6 to 22/-
Best Steam Smalls	14/6 to 15/6
Ordinary „	11/- to 14/-
Washed Nuts	20/- to 27/6
No. 3 Rhondda Large	29/- to 29/6
„ „ Smalls	18/- to 19/-
No. 2 „ Large	23/- to 24/-
„ „ Through	18/6 to 19/-
„ „ Smalls	14/- to 14/6
Foundry Coke (export)	40/- to 50/-
Furnace Coke (export)	27/6 to 30/-
Patent Fuel	27/6 to 28/-
Pitwood (ex ship)	27/6 to 28/-
SWANSEA—	
Anthracite Coals :	
Best Big Vein Large	34/- to 37/6
Seconds	30/- to 32/6
Red Vein	27/6 to 29/-
Machine-made Cobbles	42/6 to 47/6
Nuts	50/- to 57/6
Beans	44/- to 46/-
Peas	22/6 to 25/-
Breaker Duff	9/6 to 10/-
Rubbly Culm	14/- to 14/6
Steam Coals :	
Large	23/- to 24/-
Seconds	22/- to 23/-
Smalls	10/- to 12/6
Cargo Through	17/6 to 19/6

(1) Delivered. (2) Net Makers' works. (3) f.o.t. Makers' works, approximate. (4) Delivered Sheffield. (5) Glasgow, Lanarkshire and Ayrshire.

(6) Home Prices—All delivered Glasgow Station. Boiler Plates 10/- extra delivered England. (7) Export Prices—f.o.b. Glasgow. (8) Except where otherwise indicated, coals are per ton at pit for inland and f.o.b. for export, and coke is per ton on rail at ovens and f.o.b. for export. (9) Per ton f.o.b † Latest quotations available.

(a) Delivered Glasgow. (b) Delivered Sheffield. (c) Delivered Birmingham. * Open market price. Special price for pig iron producers, 19/- per ton at ovens.

French Engineering Notes.

(From our Correspondent in Paris.)

Trade Depression.

DESPITE the efforts that are being made to represent the industrial situation as only a little less satisfactory than the normal, there is no doubt that the iron, steel and engineering trades are becoming worse every week, and it is difficult to deny the existence of an increasing unemployment. The only reasonable ground for optimism is the probable duration of the crisis. The stabilisation of the franc for so long a time is satisfactory, and it is hoped that before long prices will recede to a normal level and prepare the way for a revival of trade. Unfortunately, the fall in living costs is so desperately slow as to have practically no effect upon the situation. Meanwhile, the position is becoming very difficult in all branches of industry. It appears even to be causing some embarrassment to the Steel Cartel, for there have been rumours pointing to serious dissensions, which, however, are due merely to a feeling of discontent amongst German steelmakers at finding themselves confronted with a heavy surplus production at a time when the demand has fallen to a minimum. During the past few months the German steel output has been above the quota, and in December last exceeded it by 25 per cent., with the result that Germany has to pay a large amount to the common fund for partial distribution amongst those countries which did not reach their quotas. Meanwhile, official quotations for export are nominal, and makers are prepared to sell below those figures if they can do business. The Rail Union appears to be operating satisfactorily on the basis of a million tons of rails for export every year, the quotas being 43 per cent. for Great Britain, 19·5 per cent, each for France and Germany, and 11 per cent. for Belgium, and 7 per cent. for Luxemburg. There is an additional 4000 tons for Czecho-Slovakia. The quota attributed to Great Britain includes the share of the United States, as railmakers in the latter country are not permitted to take part officially in any trust operations. British railmakers also have a preference for business done with the Commonwealth of Nations.

Public Works.

The Government has prepared the programme of public works which are to be carried out with a view of alleviating unemployment, and it is now being considered from the financial point of view. The Minister of Public Works explains that the principle underlying the programme is to reduce purchases abroad to a minimum, improve the balance of trade and increase the country's means of production, and, so far as his own share of the programme is concerned, he aims at providing an ample and cheap supply of motive power and at facilitating transport. At present, the country has to purchase 20 million tons of foreign coal a year, and the Minister hopes that, by effecting economies in coal getting, utilising the poorer qualities of coal to the best advantage, and increasing production, it will be possible, during the next seven years, to reduce the deficit from 20 millions to 12 million tons. It is also intended to push forward the electrification of railways, and in three years the total length of lines electrified may be increased from 560 miles to 1450 miles. It is hoped to provide the funds necessary during the next five years to put the 27,000 miles of roads in a good state of repair. Again, efforts will be made to increase the shipping tonnage from 3,500,000 tons to 5,000,000 tons, which must be done to avoid the necessity of paying freight for the transport of French goods on foreign ships, and which will be accomplished by means of loans to shipowners at a low rate of interest.

Shipbuilding.

Under the new Tariff Bill, which will come up for debate shortly, the Government proposes to encourage the shipbuilding industry by allowing the temporary free importation of practically everything required for the construction of ships to foreign orders. At present ship plates are the only materials that can be imported under those conditions. As, owing to their geographical position the shipyards are as far away from the plate mills as they possibly can be, the cost is generally too high to permit of builders competing for foreign orders, despite the preferential rates accorded for their transport, and it is now found that, if the free importation of ship plates tends to bring down costs, shipbuilders are still unable to make headway when they have to pay heavy duties on steam turbines and other machinery. The industry will either continue to decline, or shipbuilders must be offered relief from prohibitive import duties. The prospect of shipbuilders being able to import foreign machinery free of duty for the equipment of ships built for export, is arousing a strong protest from machinery makers, who affirm that their own industry will be seriously imperilled if they are not protected from the competition of foreign makers. They declare that the temporary free importation should be abandoned and replaced by the old system of bounties, whereby the shipbuilder received a premium on the tonnage exported, so that the State paid the difference between the prices of French and foreign machinery. The State, however, is quite incapable of paying bounties, and, for the time being, the temporary free importation of machinery for ships built on foreign account appears to offer the only solution of the difficulty.

The Steel Industry.

In 1926 the production of pig iron in France was 9,392,917 tons, as compared with 8,471,800 tons in the preceding year, and of steel 8,386,249 tons, as against 7,415,072 tons. Following upon such a heavy production the present slump is causing serious alarm. In the Saar basin the costs have increased so heavily, as compared with those in Westphalia, that the situation of the coal, and iron and steel trades is declared to be critical. Ironmasters state that it can only be saved by a reduction in coal prices, railway rates and wages. In the Loire, steelmakers have petitioned Government for a reduction of the present charges which, they affirm, render it quite impossible to make headway in the present crisis.

British Patent Specifications.

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

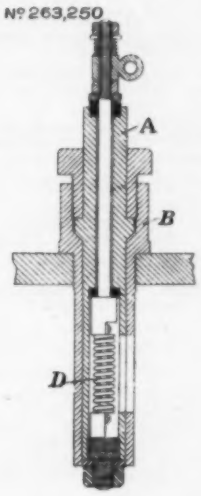
Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton-buildings, Chancery-lane, W.C., at 1s. each.

The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

INTERNAL COMBUSTION ENGINES.

263,250. October 13th, 1925.—IMPROVEMENTS IN INTERNAL COMBUSTION ENGINE IGNITION, H. Widdop and Co., Ltd., of Invincible Works, Keighley, Yorks., and Herbert Widdop, of the same address.

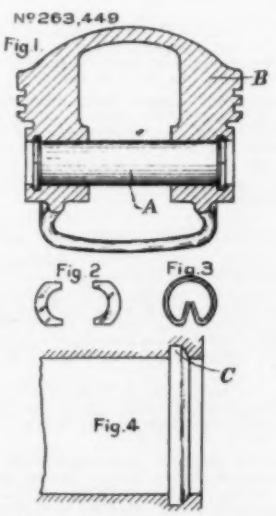
This specification describes an ignition device for an internal combustion engine in which a resistance coil is used. The sleeve A may be rotated within the outer cover B. The coil D is heated



with an electric current to the point of incandescence, to enable it to ignite the mixture of an internal combustion engine. After the engine has been started, however, the sleeve A is rotated, and the coil D is covered, so that the coil is protected against deterioration, the ignition of the charge being continued by the heated walls of the combustion chamber.—*December 30th*, 1926.

263,449. September 8th, 1926.—PISTONS, Norton Motors, Ltd., Bracebridge-street, Birmingham, and W. W. Moore.

This invention is concerned with pistons, in which it is desired that the gudgeon pin should be free to rotate, while the pin is also free in the small end of the connecting-rod. The object is to prevent the pin moving endways and rubbing against the cylinder walls. The gudgeon pin A is a push-in fit in a transverse bore in the piston B, and is substantially less in length than the diameter of the piston. An internal groove C is machined in the bore near each end of sufficient width to receive the washer and ring, and the shoulder forming the outer end of each groove is slightly tapered or inclined, as shown in Fig. 4.

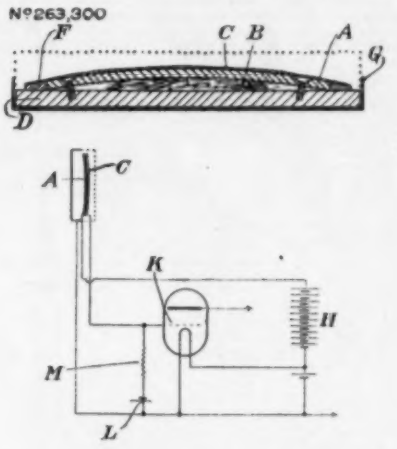


The washer—shown in Fig. 2—consists of a flat annular washer divided diametrically, and each half has opposed flats to permit it to be inserted into the groove C. The retaining ring—Fig. 3—consists of a ring of spring wire with the ends inturned as shown, so that they can be gripped by a tool for removal of the ring. In assembling the parts, the gudgeon-pin is pushed into place, the two halves of the washer are inserted into the groove, and the retaining ring is sprung into the groove outside the washer. The retaining ring bears against the inclined outer face of the groove so that it tends to be wedged against the washer and cannot be displaced by an axial movement of the gudgeon pin.—*December 30th*, 1926.

TELEGRAPHS AND TELEPHONES.

263,300. December 21st, 1925.—IMPROVEMENTS IN OR RELATING TO CONDENSER TELEPHONES, Paul Gustavus Adolphus Helmuth Voigt, of "Bowdon, Mount," 121, Honor Oak Park, London, S.E. 23.

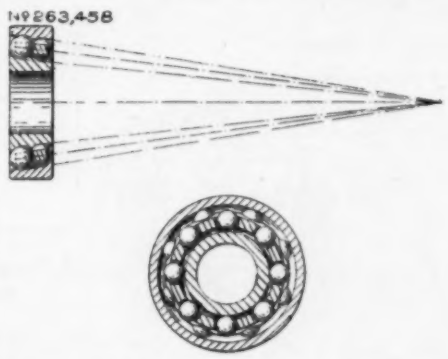
The principal characteristic of microphones made according to this invention is that the movable electrodes are so flexibly mounted that the restoring forces due to such mounting are negligible compared with those due to the elasticity of a gas cushion at acoustic frequencies. One is made of a heavy back electrode which may consist of a metal plate A, damped with felt B, and screwed to an insulating plate D. The other electrode consists of a piece of thin aluminium foil C, separated from the back electrode by a thin layer of air, which acts as a cushion, and to prevent short circuits a piece of dry silk cloth is usually inserted between the two. The mass of the foil, together with the springiness of the gas layer produces a resonant system, but with thin foil and a thin cushioning layer, the resonance frequency is well above 16,000 cycles per second. As the foil is not likely to be flat, the air cushion will not have a uniform thickness, and the system therefore has different resonant frequencies in different places, and no one frequency will predominate. In order to make the foil lie closer to the back electrode and increase the capacity, it is preferred to curve it slightly. The back plate is surrounded with insulating material F, to which the foil is stuck, and to prevent interference the whole microphone is surrounded by a screening case G. A battery connected across the electrodes helps to maintain silent working. The change in capacity may be converted into electrical variations with high-frequency currents by changing the wave lengths of a tuned circuit which is coupled to an oscillating circuit, thereby altering the amplitude of the currents in either circuit. One electrode A is connected to the polarising battery H, which may be the anode battery of the valve. The other electrode C is connected to the grid K of the first valve, and is maintained slightly negative by means of the battery L and grid leak M.—*December 30th*, 1926.



TRANSMISSION OF POWER.

263,458. September 3rd, 1926.—BALL BEARINGS, The Auto Machinery Company, Ltd., and B. Needham, Hood-street, Coventry.

This ball bearing is claimed to be exceptionally narrow, for the load which it will carry, and also to the capable of sustaining

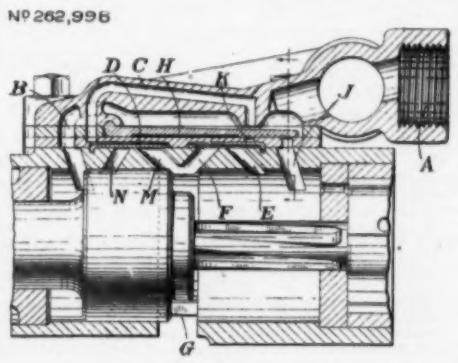


end thrust. It has two rows of balls, which are spaced so closely axially, that the balls belonging to one race overlap those of the other race. The two sets are positioned by one cage. The races are also arranged in conical formation, as shown by the dotted lines.—*December 30th*, 1926.

MINING MACHINERY.

262,998. March 6th, 1926.—ROCK DRILLS, Holman Brothers, Ltd., A. T. Holman, and P. M. Holman, Camborne, Cornwall.

In the operation of this rock drill compressed air enters the

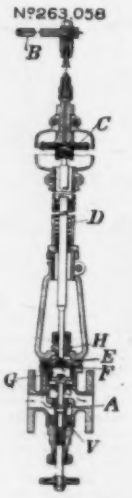


inlet A and passes over the valve—in the position illustrated—to the left-hand end of the cylinder through the passage B. Air is also admitted through the passage C to the upper surface of the valve D, and retains it in its closed position. As the piston

travels to the right, the back pressure, which would otherwise be produced in the right-hand end of the cylinder, is released through the ports E and F, and the exhaust port G, until the port E is closed. When the piston covers the port E it simultaneously, or practically simultaneously, opens the exhaust port G, thereby reducing the pressure on the top of the valve H by the sudden rush of air through the free release port G. Further travel of the piston to the right compresses air through the port J beneath the valve H, and lifts the la ter, whereby admission of air to the passages B and C is cut off and air is admitted through the port J to the right-hand face of the piston, and also through the port K to the upper surface of the valve controlling the ports E and F. This valve then closes down over those ports and the piston commences to move to the left, whereupon pressure from the left-hand end of the cylinder is released through ports M and N until the port M is closed and the port G opened. The pressure is then suddenly released from the right-hand end of the cylinder, and compression taking place through the passage, reseats the valve H in its lower position, and the cycle of operations is repeated.—*December 23rd*, 1926.

MISCELLANEOUS.

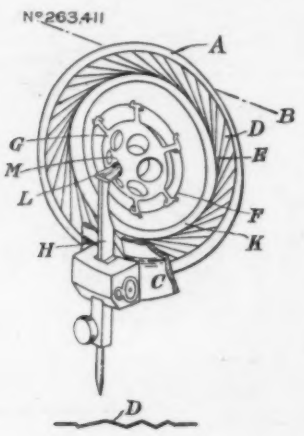
263,058. July 31st, 1926.—THERMOSTATIC CONTROL VALVES, W. B. Dale, R. A. Hopkinson and Hopkinsons, Ltd., Britannia Works, Huddersfield.



The operation of this device is as follows:—Upon a fall in temperature of the medium being heated by the steam or other fluid passing through the valve A, the volatile liquid in the thermostat bulb B, which is inserted in the medium being heated, will cool and the vapour pressure fall. The diaphragm C will then be raised by the spring D and the aperture E uncovered. The steam or other fluid at the inlet side of the valve A will then gain access to the cylinder F, and by reason of the difference in areas between the piston G and valve A the latter will be opened or further opened. If the temperature of the heated medium rises, the aperture E will be closed by the pilot valve H, the pressure acting on the piston G will fall, owing to leakage past the piston, and the valve A will be closed, thus reducing the amount of heat being conveyed to the medium.—*December 23rd*, 1926

263,411. September 22nd, 1925.—IMPROVEMENTS IN DIAPHRAGMS, *Standard Telephones and Cables, Ltd., of Connaught House, Aldwych, London, W.C. 2.*

One object of this invention is to provide a diaphragm which is very readily responsive to sound waves or other forces applied thereto. The diaphragm A has a flat annular edge portion B adapted to be held in the usual way between gaskets in the sound box casing, part of which is shown at C. Within this annular flat portion is a zone D which is provided with corrugations disposed tangentially to the circle E, concentric with the edge of the diaphragm. The area within the tangentially corrugated zone D is stiffened by a concentric corrugation F, to the ridge of which are fastened the arms of the spider G connecting the diaphragm to the stylus bar H. In the construction illustrated there is a flat portion or zone K left between the tangentially corrugated portion D and the concentrically corrugated portion F. The tendency of the tangential corrugations to move, when the diaphragm is vibrated, from the tangential towards the radial position, is calculated to produce a slight turning movement of the central stiffened portion of the diaphragm, and to take account of this the stylus bar H is connected with the diaphragm spider G so as to permit of a turning movement between the two parts. The end L of the stylus bar may be bifurcated as shown, and the two arms of the fork notched on their outer sides to engage with the edge of the circular opening M in the centre of the spider.—*December 22nd*, 1926.



CHEAP POWER.—From Ruston and Hornsby, Ltd., of Lincoln, we have received a very interesting little booklet on "Cheapest Electricity and How to Obtain It." It contains many forcible arguments in favour of the small power plant and against the super power station, which is believed by some to be the only means of supplying this country with cheap power. Figures given in the booklet indicate, however, that the power user can generate his own current more cheaply than he can purchase it from an outside source, and that the advantages claimed for the Government's electricity supply scheme are based on fallacies. Users of power who may be in doubt as to whether it is advisable to generate their own current or purchase it from a supply undertaking will find much in this publication which should enable them to settle the question. In order that the figures given in the book may be accepted as reliable evidence, all the costs have been obtained under normal working conditions, with the usual load factors met with in various works, and power users are recommended to compare their present costs with figures guaranteed to users of modern Ruston oil engines.

Forthcoming Engagements.

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Wednesday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

TO-DAY.

DIESEL ENGINE USERS ASSOCIATION.—Caxton Hall, Westminster, London, S.W. 1. "The Repair of a Diesel Engine Crank Shaft at the Elander-road Power House of the Karachi Electric Supply Corporation," by Messrs. Handcock and Dykes. Discussion on "Compressed Air Receivers and Proposed Regulations under the Factories (No. 2) Bill," and "Heavy Oil Engine Working Costs, 1925–26." 3 p.m.

INSTITUTION OF LOCOMOTIVE ENGINEERS: NORTH-EASTERN CENTRE.—Hotel Metropole, Leeds. Paper, "The Working of Light Traffic on Railways and the 'Sentinel' Engine," by Mr. J. W. Beaumont. 7 p.m.

INSTITUTION OF MECHANICAL ENGINEERS.—Storey's Gate, Westminster, London, S.W. 1. Informal meeting. Discussion on "Engineering Salesmanship," introduced by Mr. W. Reavell. 7 p.m.

JUNIOR INSTITUTION OF ENGINEERS.—39, Victoria-street London, S.W. 1. Paper, "The Theory of the Gyroscopic Compass," by Mr. P. R. Jackson. 7.30 p.m.

KEIGHLEY ASSOCIATION OF ENGINEERS.—Queen's Hotel, Keighley. Lecture, "Wild Cumbria," by Mr. J. W. Shuttleworth. 7.30 p.m.

ROYAL INSTITUTION OF GREAT BRITAIN.—21, Albemarle-street, London, W. 1. "Wireless Transmission and the Upper Atmosphere," by Professor E. V. Appleton. 9 p.m.

SATURDAY, FEBRUARY 5TH.

INSTITUTE OF BRITISH FOUNDRYMEN: LANCASHIRE BRANCH.—Grand Hotel, Aytoun-street, Manchester. Lecture, "Early History of the Institute." 4 p.m. Followed by the annual dinner at 6 for 6.30 p.m.

INSTITUTION OF AUTOMOBILE ENGINEERS: WESTERN CENTRE.—Law Courts, Cardiff. Paper, "Maintenance in the United States," by Mr. J. Younger. 6.30 p.m.

KEIGHLEY ASSOCIATION OF ENGINEERS.—Visit to the Corporation gasworks at Thwaites. 2.45 p.m.

MONDAY, FEBRUARY 7TH.

BRADFORD ENGINEERING SOCIETY.—Technical College, Bradford. Lecture, "The Electric Driving of Textile Machinery," by Messrs. R. H. Friend and A. Brier. 7.30 p.m.

INSTITUTION OF AUTOMOBILE ENGINEERS: WESTERN CENTRE.—Merchant Venturers' Technical College, Bristol. Paper, "Supercharging of Aircraft and Motor Vehicle Engines," by Mr. A. H. R. Fedden. 6.45 p.m.

ROYAL INSTITUTION OF GREAT BRITAIN.—21, Albemarle-street, London, W. 1. General meeting. 5 p.m.

SOCIETY OF ENGINEERS.—Geological Society's Rooms, Burlington House, Piccadilly, London, W. 1. Presidential address by Mr. D. C. Fidler. 5.30 p.m.

SURVEYORS' INSTITUTION.—12, Great George-street, London, S.W. 1. Paper, "The Garden Squares of London," by Mr. F. W. Hunt. 8 p.m.

TUESDAY, FEBRUARY 8TH.

INSTITUTE OF MARINE ENGINEERS.—85–88, The Minories, Tower Hill, London, E. 1. Paper, "Feed-water Circuits for Marine Installations," by Mr. J. G. Weir. 6.30 p.m.

INSTITUTION OF AUTOMOBILE ENGINEERS: COVENTRY CENTRE.—Broadgate Café, Coventry. Paper, "The Supercharging of Aircraft and Motor Vehicle Engines," by Mr. A. H. R. Fedden. 7 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS: SCOTTISH CENTRE.—McLellan Galleries, 270, Sauchiehall-street, Glasgow. Faraday Lecture, "What is Electricity?" by Professor W. M. Thornton. 7.30 p.m.

INSTITUTION OF PETROLEUM TECHNOLOGISTS.—Royal Society of Arts, John-street, Adelphi, London, W.C. 2. Paper, "The Production of Oil from Coal: An Account of the Work of the Fuel Research Station," by Dr. C. H. Lander. 5.30 p.m.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS: MIDDLESBROUGH BRANCH.—Cleveland Scientific and Technical Institution, Corporation-road, Middlesbrough. "Some Notes on Naval Architecture," by Mr. O. Hirst. 7.30 p.m.

SHEFFIELD METALLURGICAL ASSOCIATION.—198, West-street, Sheffield. Paper, "Valve Steels," by Mr. P. B. Henshaw. 7.30 p.m.

WEDNESDAY, FEBRUARY 9TH.

BOROUGH POLYTECHNIC INSTITUTE.—Borough-road, London, S.E. 1. Annual prize distribution. 7.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS: SOUTH MIDLAND CENTRE.—Birmingham and Midland Institute, Paradise-street, Birmingham. Annual joint meeting with the local branches of the Institutions of Civil and Mechanical Engineers. Faraday lecture, "What is Electricity?" by Professor W. M. Thornton. 7 p.m.

INSTITUTION OF ENGINEERS-IN-CHARGE.—St. Bride Institute, Bride-lane, Fleet-street, London, E.C. 4. Paper, "The Use of Oil Engines for Private Installations," by Mr. A. W. Wyatt. 7.30 p.m.

INSTITUTION OF HEATING AND VENTILATING ENGINEERS.—Holborn Restaurant, London, W.C. 1. Annual general meeting. Presidential address by Mr. J. L. Musgrave. Paper, "The Effect of Weather Conditions upon the Heat Requirements of a House," by Dr. Margaret Fishenden. 2.30 p.m.

INSTITUTION OF WELDING ENGINEERS.—Milton Hall, Deansgate, Manchester. Paper, "The Welding of Cast Iron," by Mr. P. L. Roberts. 7 p.m.

ROYAL SOCIETY OF ARTS, John-street, Adelphi, London, W.C. 2. "The Romance of the Organic Chemical Industry," by Dr. E. F. Armstrong. 8 p.m.

THURSDAY, FEBRUARY 10TH.

INSTITUTE OF METALS: LONDON LOCAL SECTION.—Society of Motor Manufacturers and Traders, 83, Pall Mall, London, S.W. 1. Joint meeting with the Electroplaters' and Depositors' Technical Society. "Nickel Coatings—Methods of Production," by Mr. W. R. Barclay. 7.30 p.m.

INSTITUTION OF AUTOMOBILE ENGINEERS.—Midland Hotel, Derby. Derby Graduates' annual dinner and smoking concert. 7.15 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS.—Hotel Cecil, Strand, London, W.C. 2. Annual dinner. 7.15 for 7.45 p.m.

ROYAL INSTITUTION OF GREAT BRITAIN.—21, Albemarle-street, London, W. 1. "Acoustical Problems," by Sir William Bragg. 5.15 p.m.

FRIDAY, FEBRUARY 11TH.

ELECTROMOBILE ASSOCIATION.—Royal Society of Arts, John-street, Adelphi, London, W.C. 2. Informal meeting. Discussion on "The Use of Storage Battery Type Electromobiles," to be opened by Mr. J. C. Elvy. 7 p.m.

INSTITUTE OF METALS: SHEFFIELD LOCAL SECTION.—Applied Science Department of the University, St. George's-square, Sheffield. "Bronze," by Mr. R. T. Rolfe. 7.30 p.m.

INSTITUTE OF METALS: SWANSEA LOCAL SECTION.—Metallurgical Department of the University, Singleton Park, Swansea. "The Design of Annealing Furnaces," by Mr. J. S. Caswell. 7.15 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS: SOUTH MIDLAND STUDENTS' SECTION.—Visit to the Witton destructor works. 7.15 p.m.

JUNIOR INSTITUTION OF ENGINEERS.—39, Victoria-street, London, S.W. 1. Honorary members' lecture, "The Physiology of Work under High Air Temperature Conditions," by Professor K. Neville Moss. 7.30 p.m.

NORTH-EAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Literary and Philosophical Society's Rooms, Newcastle-upon-Tyne. "Psychology as an Aid to Efficiency and Economy in Industry," by Professor F. Smith. 6 p.m.

ROYAL INSTITUTION OF GREAT BRITAIN.—21, Albemarle-street, London, W. 1. "Old Hampton Court Palace Revealed," by Mr. Ernest Law. 9 p.m.

MONDAY, FEBRUARY 14TH.

INSTITUTE OF METALS: SCOTTISH LOCAL SECTION.—Institution of Engineers and Shipbuilders, 39, Elmbank-crescent, Glasgow. "Notes on Aluminium Alloys," by Mr. D. R. Tullis. 7.30 p.m.

ROYAL SOCIETY OF ARTS.—14, John-street, Adelphi, London, W.C. 2. Cantor Lecture, "Photo-elastic Measurements of Stress Distribution," by Professor E. G. Coker. 8 p.m.

TUESDAY, FEBRUARY 15TH.

INSTITUTE OF BRITISH FOUNDRYMEN: LANCASHIRE BRANCH, BURNLEY SECTION.—Municipal College, Ormerod-road, Burnley. Paper, "Strickle Moulding from the Spindle," by Mr. L. Wharton. 7.15 p.m.

INSTITUTION OF AUTOMOBILE ENGINEERS: WOLVERHAMPTON CENTRE.—Engineering and Scientific Club, Queen-street, Wolverhampton. Paper, "The Supercharging of Aircraft and Motor Vehicle Engines," by Mr. A. H. R. Fedden. 7.30 p.m.

WEDNESDAY, FEBRUARY 16TH.

CHAMBER OF SHIPPING OF THE UNITED KINGDOM.—Hotel Victoria, Northumberland-avenue, London, W.C. 2. Annual Dinner. 6.30 for 7 p.m.

ROYAL SOCIETY OF ARTS.—John-street, Adelphi, London, W.C. 2. "Some Studies in Connection with the Manufacture of Electric Lamps and Thermionic Valves," by Mr. C. C. Paterson. 8 p.m.

THURSDAY, FEBRUARY 17TH.

CHAMBER OF SHIPPING OF THE UNITED KINGDOM.—Leathersellers' Hall, St. Helen's-place, London, E.C. 3. Fiftieth annual meeting.

FRIDAY, FEBRUARY 18TH.

INSTITUTION OF LOCOMOTIVE ENGINEERS.—The Engineers' Club, Coventry-street, London, W. 1. Annual dinner. 6.30 for 7 p.m.

FRIDAY, FEBRUARY 25TH.

INSTITUTION OF CIVIL ENGINEERS: BIRMINGHAM AND DISTRICT ASSOCIATION.—Grand Hotel, Birmingham. Annual dinner. 6.30 for 7 p.m.

CONTRACTS.

DAVIDSON AND CO., Ltd., of Belfast, have received from the Durban Navigation Collieries of South Africa an order to supply one of the most powerful mine fans yet constructed. It is to be capable of dealing with 700,000 cubic feet of air per minute against a resistance of 7in. of water gauge, and it will require a steam engine of 1200 horse-power to drive it.

SAXBY AND FARMER (India), Ltd., of Calcutta, a company which is associated with the Westinghouse Brake and Saxby Signal Company, Ltd., of London and Chippenham, has been given the contract for the supply of Westinghouse semi-automatic daylight signals, and A.C. track circuiting over approximately three miles of double track, between Churchgate and Grant-road, on the Bombay, Baroda and Central India Railway, the control apparatus for these signals being arranged in four cabins.

SIEMENS BROTHERS AND CO., Ltd., of Woolwich, announce that the following are among the telephone exchanges completed by them during 1926:—Automatic: Chesterfield; Edinburgh area, four exchanges; East Hartlepool; West Hartlepool; Morriston; Stavely; Albion and Newmarket, Australia; Winnipeg West, Canada; Stratford, New Zealand; Cairo; Port Elizabeth extension, South Africa; Baku, Russia; also extensions to Grimsby, Swansea and Sketty. Manual: Bexley Heath; Camberley; Dumfries; Popesgrove; Seven Kings; Shipley; and Southend.

RANSOMES AND RAPIER, Ltd., of Ipswich, and 32, Victoria-street, Westminster, London, S.W. 1, have recently secured orders for a Ransomes-Rapier-Marion ("R.-R.-M.") steam dragline excavator for the Punjab Government, Irrigation Branch; and for a "R.-R.-M" full electric voltage controlled shovel dragline-grabbing excavator for the Punjab Government, Hydro-electric Circle. These machines are the first British-built Marion excavators ordered for India. The same firm has also recently received orders for dragline excavators for New Zealand, Australia, and South Africa, and for a steam shovel for quarries in Yorkshire.

HENRY SIMON, Ltd., of Manchester, have received from the Bristol Docks Committee an order for machinery in connection with an important extension scheme which it is carrying out, with the object of improving the grain-handling facilities at Avonmouth docks. The order includes (*a*) the machinery equipment of the new transit granary No. 3, built in connection with the Eastern Arm Extension to the Royal Edward Dock, of No. 4 granary, and of the sheds and galleries connecting up to those granaries; (*b*) alterations to existing conveying and elevating machinery in Nos. 1 and 2 granaries, to raise the capacity from 100 to 170 tons per hour; and (*c*) the contract also includes the installation of four receiving conveyor bands, approximately 1600ft. long, at the Eastern Arm Extension. The approximate total length of the new conveyors which are to be installed will be about 3 miles.

INSTITUTION OF MECHANICAL ENGINEERS: ERRATUM.—In our report of the discussion on Professor Mellanby and Professor Kerr's paper in last week's issue, it was made to appear that the pressure to be employed for the new Bradford high-pressure set will be 11,000 lb. per square inch. This figure was misprinted for 1100 lb.